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STATISTICAL METHODOLOGY FOR ASSIGNING EMISSIONS TO INDUSTRIES IN THE UNITED STATES: 1970 TO 1990

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SUMMARY

This report presents the results of a study that develops a methodology to assign emissions to the manufacturing and nonmanufacturing industries that comprise the industrial sector of the EPA's national emission estimates for 1970 to 1990. First, the methodology followed by the U.S. EPA to estimate national emissions of the six criteria air pollutants is described. Next, the procedures employed in this study to assign emissions to specific industries are discussed. Finally, the methodology is implemented and the emission estimates for each of the industries are presented in two spreadsheets. The U.S. EPA has replaced the methodology that derives the emissions used in this report. As a result, the U.S. EPA revised its estimates of emissions for 1970 to 1990. *Statistical Methodology for Assigning Emissions to Industries in the United States, Revised Estimates: 1970 to 1997* uses many of the procedures developed in this report to assign the revised estimates of emissions for 1970 to 1997.

This is a technical report whose intended audience consists of individuals interested in developing environmental accounts.

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ACRONYMS AND ABBREVIATIONS

AIRS	Aerometric Information Retrieval System
AIRS/FS	AIRS Facility Subsystem
AP-42	*Compilation of Air Pollutant Emission Factors*
ASM	*Annual Survey of Manufactures*
BEA	Bureau of Economic Analysis, U.S. Department of Commerce
BOF	basic oxygen furnace
Br	brass
Btu	British thermal unit
CO	carbon monoxide
Cu	copper
DAEMEC	*Derived Annual Estimates of Manufacturing Energy Consumption*
EAF	electric arc furnace
EIA	Energy Information Administration, U.S. Department of Energy
Eurostat	Statistical Office of the European Communities
ex.	excluding
excl.	excluding
Fe	ferro
Fe-Mn	ferromanganese
Ferro-Mg-E1	ferromanganese produced by electric furnaces
Ferro-Mg-B1	ferromanganese produced by blast furnaces
Fe-Si	ferrosilicon

ACRONYMS AND ABBREVIATIONS
(continued)

FCC	fluid catalytic cracking
HD	high density
HSS	Horizontal Stud Soderberg
incl.	including
LD	low density
LPG	liquefied petroleum gas
MECS	Manufacturing Energy Consumption Survey
MOBILE-4	Mobile Source Emissions Model, U.S.EPA
NAICS	North American Industrial Classification System
NAMEA	National Accounting Matrix including Environmental Accounts
NAPAP	National Acid Precipitation Assessment Program
NEA	National Energy Accounts
n.e.c.	not elsewhere classified
NEDS	National Emissions Data System
1940-1990 NAPEE	*National Air Pollutant Emission Estimates, 1940-1990*
1970-1997 NAPET	*National Air Pollutant Emission Trends Update: 1970-1997*
1970-1997 Revised Estimates	*Statistical Methodology for Assigning Emissions to Industries in the United States, Revised Estimates: 1970-1997*
NO	nitric oxide (NO)
NO_x	oxides of nitrogen
Pb	lead

ACRONYMS AND ABBREVIATIONS
(continued)

PM	particulate matter
PM-10	particulate matter less than 10 microns in diameter
POTW	publicly owned treatment works
pt.	part
PVC	polyvinyl chloride
SCC	source classification code(s)
SEDR	*State Energy Data Report*
Si	silicon
SIC	Standard Industrial Classification (code)
SEEA	System for Integrated Environmental and Economic Accounts
SiMn	silicomanganese (or silicon manganese)
SO_2	sulfur dioxide
SO_3	sulphur trioxide
SO_x	oxides of sulfur
TEL	TetraEthyl lead
TiO2	titanium dioxide
TML	TetraMethyl lead
TCC	thermal catalytic cracking
TSDF	hazardous waste treatment, storage, and disposal facilities
U.N.	United Nations

ACRONYMS AND ABBREVIATIONS
(continued)

U.S. BOM	U.S. Bureau of Mines
U.S. DOE	U.S. Department of Energy
U.S. DOI	U.S. Department of Interior
U.S. DOT	U.S. Department of Transportation
U.S. EPA	U.S. Environmental Protection Agency
U.S. FHWA	U.S. Federal Highway Administration
U.S. ITC	U.S. International Trade Commission
VMT	vehicle miles traveled
VSS	Vertical Stud Soderberg
VOC	volatile organic compound(s)
Zn	zinc

1. INTRODUCTION

In recent years, national and international statistical agencies have exhibited increasing interest about the subject of environmental accounting.[1] The United Nations (1993) developed guidelines for integrating environmental-economic satellite accounts. Nestor and Pasurka (1995) present a brief summary of the four parts of the United Nations (U.N.) framework for environmental and natural resource accounts. Since emissions are assigned to specific industries in this report, it can be viewed as an application of the System for Integrated Environmental and Economic Accounts (SEEA).

The first phase of environmental accounting is organizing data related to environment-economy interactions. Nestor and Pasurka (1995) incorporated U.S. environmental protection costs into an input-output framework in a manner that was consistent with the U.N. guidelines. This framework was also used to estimate the size and employment associated with the "environmental protection industry" (see U.S. EPA, 1995a and 1995b).[2]

The second phase of environmental accounting is the development of physical data on environmental-economic interactions. The Statistical Office of the European Communities (1999) has supported the development of physical accounts known as National Accounting Matrices including Environmental Accounts (NAMEA). The NAMEAs assemble information on emissions and energy consumption for individual industries. The German (see Stahmer, Kuhn, and Baum, 1998), Danish (see Jensen and Pedersen 1998) and Dutch (see Keuning and DeHaan, 1998) statistical offices are among the agencies developing NAMEAs.

Several uses of information on emissions from industries have been proposed. Among the proposed applications are indicators of environmental performance that measure changes in emissions to changes in output over time. The estimates of emissions from industries can be linked to input-output tables, which makes it possible to estimate the quantity of pollutants associated with final demand categories. Finally, adjusted measures of productivity, which credit an industry for

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[1] The Bureau of Economic Analysis (BEA) published its initial work in the area of environmental / natural resource accounting in the April 1994 issue of the *Survey of Current Business* (U.S. Department of Commerce, Bureau of Economic Analysis, 1994a, 1994b). The National Academy of Sciences conducted a review, *Nature's Numbers: Expanding the National Economic Accounts to Include the Environment* (Nordhaus and Kokklenberg 1999), of the BEA work in environmental accounting. The Overview (November 1999), Chapter 3 (February 2000), Chapter 4 (March 2000), and Chapter 5 (November 1999) of *Nature's Numbers* were reprinted in the *Survey of Current Business* (the issue is listed in parentheses) and are available at the following URL: http://www.bea.doc.gov/bea/pubs.htm.

[2] After reporting data for 1994, *Pollution Abatement Costs and Expenditures* (U.S. Department of Commerce, Bureau of the Census, 1996) and the annual "Pollution Abatement and Control Expenditures" report in the *Survey of Current Business* (Vogan, 1996), which were the basis of the Nestor and Pasurka (1995) and the U.S. EPA (1995a, 1995b) studies, were discontinued.

reducing emissions, can be estimated by linking its emissions with the input and output data used to estimate traditional measures of productivity.[3]

The U.S. Environmental Protection Agency (EPA) has published annual estimates of emissions at the national level of the six criteria air pollutants since 1972. The EPA is required to collect and report information on national trends for each of the six criteria air pollutants regulated federally under the provisions of Section 109 of the Clean Air Act -- sulfur dioxide (SO_2),[4] oxides of nitrogen (NO_x), volatile organic compounds (VOCs), particulate matter (PM), carbon monoxide (CO) and lead (Pb). These estimates were published in the *National Air Pollutant Emission Estimates* (for example, U.S. EPA, 1991a), which has been renamed the *National Air Pollutant Emission Trends* (for example, U.S. EPA, 1995c), and the *National Air Quality and Emission Trends Report* (for example, U.S. EPA, 1991b). In these publications, the EPA presents annual estimates of emissions of the six criteria pollutants at an aggregate level for several categories of fuel combustion, industrial processes, mobile sources, and solid waste disposal and miscellaneous sources.

1.1. *Purpose of the Project*

The purpose of this project is to develop a methodology that assigns the national estimates of criteria air pollutant emissions, which are assembled by the EPA for the industrial sector, to the individual industries that belong to the industrial sector.[5] Estimates of emissions are generated for 1970 to 1990 for stationary source emissions from the industries of the industrial sector, the electric utilities sector, and the gas utilities sector.[6] This is a technical report whose intended audience consists of individuals interested in developing environmental accounts.

Emissions from industrial fuel combustion are assigned to industries based on their consumption of fuel for heat and power. The primary sources of energy consumption data are the National Energy Accounts (NEA), the *Derived Annual Estimates of Manufacturing Energy Consumption* (DAEMEC) (U.S. Department of Energy, 1992 and 1998), and the *Manufacturing*

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[3] Nestor and Pasurka (1998, pp. 140-141) discuss additional applications of the estimates of emissions by industry.

[4] The Clean Air Act regulates emissions of SO_2. However, EPA measures the emissions of SO_x as a proxy for SO_2 emissions. SO_x emissions are expressed as the equivalent SO_2 weight of SO_x.

[5] The industrial sector consists of the industries in Agriculture, Mining, Construction, and Manufacturing.

[6] Stationary source emissions consist of emissions from sources other than (1) on-road (i.e., highway) vehicles and (2) non-road mobile sources.

Energy Consumption Survey (MECS).[7] The emissions of industrial processes are assigned to industries that are defined by their NEA and Standard Industrial Classification (SIC) codes.[8] The emissions from processes are taken directly from the TRENDS data.[9] The emissions from the electric utilities and gas utilities sectors are also taken directly from the TRENDS data. Among the sources of emissions excluded from this report are VOC emissions from solvent evaporation and all mobile source emissions. The NEA estimates the fuel consumption for transportation by industries; however, there has been no attempt to estimate this category of fuel consumption after 1985. As a result, emissions from mobile sources are excluded since it is not possible to allocate their emissions among the industries of the industrial sector.

The first spreadsheet (NEA7085.WK3) consists of estimates of emissions for 1970 to 1985 for those NEA industries that belong to the industrial sector, the electric utilities sector, and the gas utilities sector. The second spreadsheet (SIC7090.WK3) includes emission estimates for 1970 to 1990 for the twenty two-digit SIC manufacturing industries (SIC 20-39), the electric utilities sector, and the gas utilities sector.

After *National Air Pollutant Emission Estimates, 1940-1990* (U.S. EPA, 1991a) was released, the U.S. EPA changed its methodology to estimate emissions.[10] After 1984, the "top-down" methodology, which was the basis of the estimates of emissions used in this report, was replaced by a modified "bottom-up" methodology. In addition, the U.S. EPA revised its estimates of emissions for 1970 to 1984. *Statistical Methodology for Assigning Emissions to Industries in the United States, Revised Estimates: 1970 to 1997* (U.S. EPA, 2000) employs many of the procedures developed in this report to assign emissions for 1970 to 1997 to the twenty two-digit SIC manufacturing industries.

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[7] Throughout the remainder of this report, the 1985 MECS, 1988 MECS, 1991 MECS and 1994 MECS refer to the U.S. Department of Energy (U.S. DOE) publications (U.S. DOE, 1988, 1991, 1994, 1997) that report the results of the triennial *Manufacturing Energy Consumption Survey*.

[8] The Source Classification Code(s) (SCC) associated with the different source categories are discussed in Section 3.0 of the *National Air Pollutant Emissions Trends Procedures Document, 1900-1996 Projections 1999-2010* (U.S. EPA, 1998)

[9] Until 1991, EPA derived national emission estimates for its major source categories using the TRENDS methodology. EPA continues to use the term "Trends" in later year reports to refer to the methodology employed in that year. In this report, "TRENDS" refers to the methodology used to generate the emissions data in the *National Air Pollutant Emission Estimates, 1940-1990* (U.S. EPA, 1991a), which is the source of the emission estimates used by this report.

[10] Throughout the remainder of this report, the *1940-1990 NAPEE* refers to *National Air Pollutant Emission Estimates, 1940-1990*.

1.2. *Organization of the Report*

The remainder of this report is organized in the following manner. Section 2 discusses the important elements of the TRENDS methodology that was used by the EPA for its reports on the trends of emissions for 1970 to 1990 (published until the 1991 report). The industry-level emission estimates, which are contained in the two spreadsheets, are based on the TRENDS methodology. In Section 3, the assumptions required to allocate emissions between industries and the step-by-step process of assigning emissions are discussed. Finally, Section 4 summarizes the report.

Appendix A lists the concordance between the source categories of emissions and the SIC and NEA codes. The concordance among the twenty two-digit SIC manufacturing industries and the NEA codes is shown in Appendix B. Appendix C lists the NEA industry titles and corresponding SIC codes of the NEA codes that comprise the industrial sector. Appendix D contains a comparison of how the assignment of process emissions to industries (i.e., SIC codes) in this report differs from the assignments made in the *1940-1990 NAPEE*.[11] Appendix E lists the estimates of emissions for the twenty two-digit SIC manufacturing industries (SIC 20-39) for the criteria air pollutants for 1970 through 1990. Appendix F describes the organization of the two spreadsheets. Finally, Appendix G describes the preparation of the report and the peer review process.

2. THE EPA'S NATIONAL EMISSION ESTIMATES

2.1. *Sources of Emissions*

There are three approaches to estimating emissions in a particular area or country:

(1) individual sources of emissions can be continuously monitored,
(2) site-specific emission test data and process information can be used to generate emission estimates, or
(3) national estimates can be generated using a combination of engineering assumptions, economic indicators, and energy statistics.

The first of these methods, the continuous monitoring of emissions, is seldom employed outside of the utility industry and other large facilities. The third method, commonly referred to as "top-down" estimation, is considered the least accurate of the three, but is employed to calculate national estimates because of the difficulty of obtaining a complete data set using the other two methods. The second method, using a combination of site-specific information and industry average factors, is frequently used at the state and local level to determine facility compliance with permitted limits, and to provide emissions data for local and regional air quality modeling.

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[11] Except for lead emissions, the *1940-1990 NAPEE* (U.S. EPA, 1991a, pp. 76-81) assigns SIC codes to aggregated source categories of emissions from industrial processes. The *1940-1990 NAPEE* did not assign SIC codes to emissions from (1) Petroleum Marketing & Production, (2) Surface Coating operations, (3) Miscellaneous Organic Solvent Evaporation, and (4) fuel combustion for heat and power.

Because of the technology requirements and the high cost of monitoring emissions, the TRENDS methodology used - with a few exceptions - the “top-down” approach. This section is limited to a discussion of the estimates generated by the TRENDS methodology. The EPA used the TRENDS methodology to determine emissions for major source categories by aggregating estimated emissions from more than 450 individual source categories (U.S. EPA, 1991a, p.1). These categories include nearly all major sources of anthropogenic emissions.

Table 1 lists the major source categories for which the EPA estimated emissions. It also shows the subcategories associated with each major source category from which the EPA estimates were derived. Table 2 lists the estimates of one pollutant, PM, for each of the source categories and subcategories. This table shows the level of disaggregation for emissions provided in the annual EPA reports on emissions trends (U.S. EPA, 1991a).

The TRENDS methodology is considered to be a "top-down" approach because it estimated emissions at the national level, as opposed to a "bottom-up" approach in which emissions are measured at the individual boiler level and then added up. In general for the TRENDS methodology, the EPA used published national activity data and standard emission factors when generating its estimates of national emissions. For each report from 1970 to 1990, the EPA updated the previous year’s estimates using current year changes in economic activity for the source categories and changes in emission factors based on the most current understanding of processes that generate emissions (U.S. EPA, 1991a, p. vii.).

The TRENDS methodology estimates emissions from the largest sources of pollution (those thought to be emitting more than 100 tons of a pollutant per year). Since the TRENDS methodology was an accounting of the emissions of the major polluters, it tended to underestimate the actual level of emissions.

2.2. *Methodology*

In general, the TRENDS methodology estimated the total emissions of a pollutant from fuel combustion or a process by multiplying the level of economic activity (e.g., fuel consumption or deliveries, vehicle miles traveled, raw material processed, etc.) by an *emission factor* -- the emissions produced per unit of economic activity. When pollution control devices are installed, total emissions are determined by multiplying that result by one minus the *control efficiency*.[12] For example, a coal-fired utility can install scrubbers that reduce its emissions by 90 percent. In this instance, the control efficiency of the utility is 90 percent. The relationship between economic activity, emission factors and control efficiencies can be expressed as follows:

[12] Emission factors are based on expert judgment and testing.

Table 1
Major Source Categories and Subcategories for Emission Estimates

CATEGORY	SUBCATEGORY
TRANSPORTATION	Highway Vehicles (Gasoline and Diesel-Powered)
	Aircraft
	Railroads
	Vessels
	Off Highway Vehicles and Machinery
STATIONARY SOURCE FUEL COMBUSTION	Electric Utilities
	Industrial Boilers
	Commercial and Institutional Boilers and Furnaces
	Residential Furnaces and Space Heaters
INDUSTRIAL PROCESSES	Chemical Manufacturing
	Petroleum Refining
	Primary and Secondary Metals
	Iron and Steel Mills
	Mineral Products
	Food Production and Agriculture
	Industrial Organic Solvent Use
	Petroleum Product Production and Marketing
SOLID WASTE DISPOSAL	Incineration
	Open Burning
MISCELLANEOUS	Forest Fires*
	Other Burning (*Agricultural Burning, Coal Refuse Burning, and Structure Fires*)
	Miscellaneous Organic Solvents Evaporation
FUGITIVE DUST PM-10 SOURCES	Paved Roads
	Unpaved Roads
	Agricultural Tilling
	Construction Activity
	Mining and Quarrying
	Wind Erosion

* For the purposes of the 1991 report, forest fires were considered anthropogenic sources although some fires may have been caused by nature.
Source: U.S. EPA, 1991a, p. 4.
Note: The EPA estimates contain some emissions of sulphur trioxide (SO_3), but sulphur dioxide (SO_2) contributes the largest share of SO_x emissions. SO_x emissions are expressed as the equivalent weight of SO_2. Emissions of NO_x consist primarily of nitric oxide (NO) and nitrogen dioxide (NO_2). NO_x emissions are expressed as weight equivalent NO_2.

Table 2

EPA Estimates of PM Emissions from Major Source Categories and Subcategories (Teragrams/Year)

MAJOR SOURCE CATEGORY AND SUBCATEGORY	1940	1950	1960	1970	1980	1990
Stationary Source Fuel Combustion						
Electric Utilities	1.3	2.0	2.8	2.3	0.8	0.4
Industrial	3.3	2.8	1.8	1.6	0.5	0.3
Comm./Inst.	0.4	0.5	0.1	0.1	0.1	0.0
Residential	2.5	1.7	1.0	0.6	1.0	1.0
Total	7.5	7.0	5.7	4.6	2.4	1.7
Industrial Processes						
Iron and Steel Mills	3.0	3.5	1.7	1.2	0.3	0.2
Primary Metal Smelting	0.6	0.6	0.5	0.6	0.1	0.1
Secondary Metals	0.2	0.3	0.2	0.2	0.1	0.1
Mineral Products	2.0	2.9	3.8	2.9	0.7	0.5
Chemicals	0.3	0.4	0.3	0.2	0.1	0.1
Petroleum Refining	0.0	0.0	0.1	0.1	0.1	0.0
Wood Products	0.5	0.8	0.9	0.7	0.2	0.2
Food and Agriculture	0.8	0.8	0.9	0.8	0.6	0.5
Mining Operations	1.3	3.4	4.1	3.9	1.1	1.2
Total	8.7	12.7	12.5	10.5	3.3	2.8

Table 2 (continued)
EPA Estimates of PM Emissions from Major Source Categories and Subcategories (Teragrams/Year)

MAJOR SOURCE CATEGORY AND SUBCATEGORY	1940	1950	1960	1970	1980	1990
Transportation						
Highway Vehicles	0.2	0.3	0.6	0.9	1.1	1.3
Aircraft	0.0	0.0	0.0	0.1	0.1	0.1
Railroads	2.4	1.7	0.1	0.1	0.1	0.0
Vessels	0.1	0.1	0.0	0.0	0.1	0.0
Other Off Highway	0.0	0.0	0.0	0.1	0.1	0.1
Total	2.7	2.1	0.7	1.2	1.3	1.5
Solid Waste Disposal						
Incineration	0.3	0.3	0.4	0.4	0.2	0.1
Open Burning	0.2	0.3	0.5	0.7	0.2	0.2
Total	0.5	0.6	0.9	1.1	0.4	0.3
Miscellaneous						
Forest Fires	2.9	1.7	1.0	0.7	1.0	1.1
Other Burning	0.8	0.8	0.8	0.4	0.1	0.1
Total	3.7	2.5	1.8	1.1	1.1	1.2
Total of All Sources	23.1	24.9	21.6	18.5	8.5	7.5

Source: U.S. EPA 1991a, p.15.

$$E_{p,s} = A_s \times EF_{p,s} \times (1 - C_{p,s} / 100)$$

where, E = emissions
p = pollutant
s = source category
A = activity level
EF = emission factor
C = control efficiency (percent)

Table 3 lists the sources of the economic activity data and emission factors for the different source categories. In general, the national economic activity data utilized by the EPA is obtained from various sources such as *Coal Distribution, Petroleum Marketing Annual, Cost and Quality of Fuels at Electric Utility Plants* that are published by Energy Information Administration (EIA) of the U.S. Department of Energy (DOE). Emission factors are developed from engineering estimates for standard equipment and process specifications. They are not necessarily precise indicators, but rather an average rate of emissions from a large number of plants or facilities. Emission factors are generally obtained from the EPA's *Compilation of Air Pollutant Emission Factors* (also known as AP-42 factors) for stationary sources (U.S. EPA, 1985). In instances where the processes described in the AP-42 factors are not comparable to the economic activity data used in TRENDS, the AP-42 factors are aggregated in the TRENDS database to the required level.

Exceptions to the typical TRENDS method of estimating emissions include its estimates of emissions from electric power plants, copper smelters and highway vehicles (U.S. EPA, 1991a, p. 30). SO_x emissions from the electric utilities sector are calculated on a plant-by-plant basis.[13] From 1975 to 1990, SO_x emissions from copper smelters are obtained from the plants directly through the respective state air pollution agencies (U.S. EPA, 1991a, p. 30). Emissions from highway vehicles are calculated by state and by month using both the EPA's mobile source emission model, MOBILE-4, for NO_x, CO, and VOC emissions and emission factors from the EPA's *Compilation of Air Pollutant Emission Factors* for particulate emissions (U.S. EPA, 1985).

2.3. *Level of Aggregation of Industrial Emission Estimates*

The U.S. EPA estimates of emissions from the industrial sector consist of two distinct categories -- processes and fuel combustion.[14] For example, in the chemical industry, emissions are

[13] U.S. EPA (1998, pp. 3-24 and 3-25) explains the derivation of the estimates of SO_2 emissions.

[14] Industrial emissions are also produced by a third type of activity - fugitive emissions. The EPA defines “fugitive emissions” as “those emissions which could not reasonably pass through a stack, chimney, vent, or other functionally-equivalent opening” (see title 40 of the *Code of Federal Regulations*, sections 70.2 and 71.2). This definition is cited in a memo at the following URL: http://www.epa.gov/ttncaaa1/t5/meta/m4047.html.

Table 3
Economic Activity, Emission Factors, Sources of Information and Assumptions for Emission Estimates

SOURCE CATEGORY	SUB-CATEGORIES	POLLUTANT COVERED	SOURCE OF EMISSIONS FACTOR	ACTIVITY DATA REQUIRED	DATA SOURCES AND ASSUMPTIONS NOTED
STATIONARY SOURCE-COAL	Bituminous, lignite, and anthracite coal	NO_x, CO, VOC, Pb	Average emission factors representative of each category were used. In the case of sulfur oxide emissions, the emission factors included an average sulfur content value for each type of coal consumed.	Consumption of coal by source category	U.S. DOE
		SO_x	In the case of all electric utilities, the SO_x emission factor was adjusted to account for the amount of sulfur controlled by flue gas desulfurization systems, according to information reported by U.S. DOE.	Consumption of coal by source category	U.S. DOE
		PM	An overall control efficiency was obtained from Aerometric Information Retrieval System/Facility Subsystem (AIRS/FS) for all power plants combined.	Consumption of coal by source category	U.S. DOE
STATIONARY SOURCE-FUEL OIL	Residual oil, distillate oil, and Kerosene burned by electric utilities, industrial boilers, commercial and institutional boilers, furnaces and residential heaters.	All	Average emission factors and sulfur content values were calculated.	Consumption of fuel oil by end user.	U.S. DOE
STATIONARY SOURCE-NATURAL GAS	Various end-user groups	All	AP-42	Consumption of natural gas by end user.	U.S. DOE
STATIONARY SOURCE-WOOD	Wood for wood stoves and residential fireplaces. Bagasse, liquefied petroleum gas (LPG), and coke and coke-oven gas consumption	All	AP-42 or AIRS	Consumption of wood, bagasse, LPG, and coke and coke-oven gas.	Consumption of wood for wood stoves and residential fireplaces estimated by U.S. DOE. Consumption of bagasse reported in AIRS. Sales of LPG reported by U.S. DOE. Coke and coke-oven gas U.S. consumption from U.S. DOE.

Table 3 (continued)

SOURCE CATEGORY	SUB-CATEGORIES	POLLUTANT COVERED	SOURCE OF EMISSIONS FACTOR	ACTIVITY DATA REQUIRED	DATA SOURCES AND ASSUMPTIONS NOTED
STATIONARY SOURCE-WASTE OIL	Combustion of waste oil.	All	Average emission factors	Consumption of waste oil	Lead emissions from combustion of waste oil were based on information obtained from U.S. EPA Office of Solid Waste. The amount of waste oil burned was assumed to remain constant, while the Lead content of waste oil was assumed to decrease as a result of the general reduction in leaded oil and petroleum products.
INDUSTRIAL PROCESSES	Included are: petroleum product storage and petroleum marketing operations, including gasoline, crude oil and distillate fuel oil storage and transfer, gasoline bulk terminals and bulk plants, retail gasoline service stations, industrial surface coating and degreasing operations, graphic arts (printing and publishing), and dry cleaners. All of these processes involve the use of organic solvents.	All	Average emission factors were applied to various production data. Average nationwide control efficiency values for various processes obtained from published reports, the 1985 National Acid Precipitation Assessment Program (NAPAP) emission inventory, AIRS, or the National Emissions Data System (NEDS). Control efficiency of surface coating operations is derived from AIRS.	Production activity	Emissions from the consumption of organic solvents were estimated from those reported by U.S. EPA. It was assumed that all solvents consumed eventually evaporate, except in surface coating operations where some of the organic solvent vapors are controlled. Lead emissions from miscellaneous industrial processes include Lead alkyl production (a major source of Lead) and other minor sources such as type metal production, can soldering, cable covering, and miscellaneous sources. The Lead alkyl production was based on information reported by U.S. International Trade Commission (ITC). Production information for other minor sources is from U.S. DOE.
ELECTRIC UTILITY	Bituminous, lignite and anthracite coal	All	AP-42	Consumption of fuel	U.S. DOE

Table 3 (continued)

SOURCE CATEGORY	SUB-CATEGORIES	POLLUTANT COVERED	SOURCE OF EMISSIONS FACTOR	ACTIVITY DATA REQUIRED	DATA SOURCES AND ASSUMPTIONS NOTED
HIGHWAY VEHICLES	Gasoline-powered automobiles, diesel-powered automobiles, light duty gasoline trucks (less than 6,000 lbs.), light duty gasoline trucks 6,000 to 8,500 lbs. in weight, light duty diesel trucks, heavy duty gasoline trucks and buses, heavy duty diesel trucks and buses, and motorcycles	VOC, NO_x, CO	MOBILE 4.0	Vehicle miles traveled (VMT) and vehicle speeds	Prior to 1980, emissions were calculated on the national level only, with a single average annual temperature, a single gasoline volatility, a national distribution of vehicle speed and type, and a percentage of hot and cold starts. For 1980 and after, emissions were calculated on the state and monthly level using state voluntary fuel volatility guidelines obtained from the American Society for Testing and Materials, and average monthly max and min temperature in each state were utilized by MOBILE 4.0. As a result of using this new method, national VOC emission estimates were about 12 to 15 percent higher than previous estimates. In both methods, average vehicle speeds were based on published distribution of VMT -- 55 mph for interstates and other primary highways, 45 mph for other rural road, and 19.6 mph for urban streets.
		VOC	MOBILE 4.0	Ambient temperature, vehicle speeds, gasoline volatility, and other variables.	None discussed
		PM, PM-10	AP-42	VMT, speed and tire wear	Emission factors account for tire wear, brake wear and tailpipe exhaust emissions.
		Pb	Average emission factors	Gasoline consumption, gasoline lead content, percent unleaded gasoline	Lead content of gasoline in 1970 from U.S. Bureau of Mines (BOM). For subsequent years from AP-42. Percent unleaded gasoline obtained from U.S. Energy Information Agency (EIA) of the U.S. DOE.

Table 3 (continued)

Source Category	Sub-Categories	Pollutant Covered	Source of Emissions Factor	Activity Data Required	Data Sources and Assumptions Noted
Off Highway Vehicles	Farm tractors, other farm machinery, construction equipment, industrial machinery, small general utility engines such as lawn mowers and snowmobiles, and motorcycles.	All	Average emission factors	Equipment population data, annual fuel use factor, fuel deliveries of diesel fuel and gasoline sales for off-highway use.	Fuel use was estimated for each subcategory from equipment population data, and an annual fuel use factor together with fuel deliveries of diesel fuel reported by U.S. DOE for gasoline sales reported by the U.S. Department of Transportation for off-highway use.
Aircraft	Various types of aircraft	All	AP-42 for various types of aircraft. Used "average emission factors" that take into account the national mix of different types of aircraft used for general aviation, military, and commercial purposes.	Number of landings and takeoffs	U.S. Federal Aviation Administration
Railroads	None	All	Average emissions factors used that are applicable to each type of fuel. In the case of SO_x, the average sulfur content of each fuel was included in the emission factors.	Diesel and residual fuel oil consumption	EIA of the U.S. DOE
Vessels	None	All	AP-42 for diesel fuel, residual oil, and gasoline. In the case of coal-fired vessels, an "average emission factor" for coal combustion in boilers was used.	Gasoline consumption based on national boat and motor registration together with usage factors (gallons/motor/ year).	Consumption of diesel fuel, residual oil, and coal by vessels operating inside U.S. boundaries from U.S. DOE. Marine gasoline sales from U.S. DOT.
Solid Waste Disposal	None	All	Average emission factors are applied to the estimated quantities of solid waste disposal.	The emissions from this category are based on an assumed solid waste generation rate of 5.5 lbs. per capita per day.	This value was originally based on a study of solid waste collection and disposal practices. This value is adjusted each year based on information contained in AIRS/FS.

Table 3 (continued)

SOURCE CATEGORY	SUB-CATEGORIES	POLLUTANT COVERED	SOURCE OF EMISSIONS FACTOR	ACTIVITY DATA REQUIRED	DATA SOURCES AND ASSUMPTIONS NOTED
FOREST FIRES	None	All	Average emission factors applied to the estimated quantities of material burned.	Quantities of materials burned	The U.S. Forest Service and the U.S. Department of the Interior (DOI) publish information on the number of forest fires, their location and the acreage burned each year. The amount of forest biomass burned and controlled burning of forest areas in acres are estimated by the U.S. EPA each year.
AGRICULTURAL BURNING	None	All	Average emission factors	Number of acres and quantity of material burned	U.S. EPA conducted a study to obtain local agricultural and air pollution control agency estimates of the number of acres and quantity of material burned per acre in agricultural burning operations. These data were updated and used to estimate emissions based on average emission factors.
COAL REFUSE BURNING	None	All	Rough estimates were made by applying average emission factors for coal combustion to U.S. BOM data.	Number of burning coal-refuse piles	U.S. BOM
STRUCTURE FIRES	None	All	Emissions are estimated by applying average emission factors for wood combustion.	Number and type of structures damaged by fires each year.	U.S Department of Commerce.
NON-INDUSTRIAL ORGANIC SOLVENT USE	Includes nonindustrial sales of surface coatings for architectural coating, and solvent evaporation from consumer products such as aerosols, deodorants, polishes, toiletries, etc. Also includes the use of organic compounds such as general cleaning solvents, paint removers, liquefaction of asphalt paving compounds, and miscellaneous other.	All	Average emission factors	Quantity of chemical production	Total national organic solvent use was estimated from chemical production reports together with estimates of the portion of total production of each chemical for use as solvent. It was assumed that the quantity of all solvent produced is equal to the quantity necessary to make up for solvent loss by evaporations.

Table 3 (continued)

SOURCE CATEGORY	SUB-CATEGORIES	POLLUTANT COVERED	SOURCE OF EMISSIONS FACTOR	ACTIVITY DATA REQUIRED	DATA SOURCES AND ASSUMPTIONS NOTED
UNPAVED ROADS	None	PM-10	AP-42	VMT on unpaved roads. Average daily traffic volume.	Method used was similar to that developed by NAPAP. Minor modifications were: 1) used AP-42 emission factor for unpaved roads for all unpaved road surface types. 2) a plume depletion factor was not applied to the emission estimates. These two modifications were made to be consistent with the approach used for other source categories. Finally, variable (not fixed) values of vehicle speeds, weights, and number of wheels were used to develop the emission factor for unpaved roads.
PAVED ROAD RESUSPENSION	None	PM-10	AP-42. Regional PM-10 emissions from paved road resuspension were estimated by summing state-level emission estimates. A "dry days" term was included in the AP-42 emission factor equation for paved roads similar to the one used in the unpaved and emission factor, in an attempt to account for the effect of precipitation	VMT. Average daily traffic volume.	An empirical model was used to express the relationship between traffic volume and surface silt loading. Surface silt loading values were determined for various paved road function classes by U.S. EPA region. Average daily traffic volume was calculated by dividing the total VMT for a particular functional class, year, and state and then dividing by the number of days in the year. For 1985 - 1989, the total VMT (by U.S. EPA region and functional class) was obtained from U.S. Federal Highway Administration (FHWA). VMT from paved roads were calculated by subtracting the unpaved VMT from the total VMT. For 1990, the total VMT was obtained by U.S. EPA region, and rural and urban VMT. Rural and urban VMT was further subdivided into functional classes using the 1989 VMT distribution.

Table 3 (continued)

Source Category	Sub-Categories	Pollutant Covered	Source of Emissions Factor	Activity Data Required	Data Sources and Assumptions Noted
Wind Erosion	None	PM-10	Regional PM-10 wind erosion emission estimates for agricultural lands were made by modifying the NAPAP method for estimating wind erosion emissions.	Expectation of the dust flux based on the probability distribution of wind energy. Uses mean wind speed and information on threshold friction velocity any information on precipitation.	Mean wind speed, threshold friction velocity, and precipitation were used to predict the wind erosion flux potential for soils. Emission estimates were developed as part of the NAPAP utilized a 30-year wind record and thus represent a 30-year average emission estimate. The wind erosion emission estimates here use state-level, year-specific wind and activity data.
Agricultural Tilling	None	PM-10	AP-42	Agricultural tilling	Regional PM-10 emissions from agricultural tilling were made using the AP-42 emission factor equation for agricultural tilling with year-specific and state-level emission factor correction parameters and activity data.
Construction Activities	None	PM-10	None discussed	Construction activity, total number of acres of land under construction, average duration of construction.	Regional PM-10 emissions were estimated using an emissions factor for construction activity and the total number of acres of land under construction in the nation. The average duration of construction was also estimated.
Mining and Quarrying	Overburden removal, drilling and blasting, loading and unloading, and overburden replacement. Transfer and conveyance operations, crushing and screening operations, and storage and travel on haul roads are not included in the estimates.	PM-10	None discussed	Mining and quarrying production	Metallic ore emissions were calculated by assuming that for the four operations listed, the PM-10 emission factors for copper ore processing operations apply to all metallic ores. Nonmetallic ore and coal emissions were calculated by assuming that the PM-10 emissions factors for surface coal mining apply to both nonmetallic ores and coal.

Source: Compiled from U.S. EPA 1991a, pp. 29-35.

produced from the industrial process itself and from fuel combustion for heat and power. Hence, the pollutants emitted by the chemical industry when it manufactures its products are treated separately in the TRENDS methodology from those released by the energy-converting boiler.

Emissions from the combustion of fuel by the industrial sector include emissions from the combustion of coal, fuel oil, natural gas, and miscellaneous fuels consumed by all industries, except cement manufacturing, petroleum refining, iron and steel processing, glass manufacturing, and lime manufacturing.[15] Emissions from the combustion of fuel oil include emissions generated by the residual, distillate and other oil categories. Miscellaneous fuels consist of wood for wood stoves and residential fireplaces, bagasse, liquefied petroleum gas, coke and coke-oven gas, and waste oil (U.S. EPA, 1991a, p. 32).

The U.S. EPA (1998, p. 4-2) organizes the source categories of emissions of criteria pollutants into four levels (i.e., tiers). Tier I and Tier II categories are the same for each of the six criteria pollutants. Tier III categories are different for each pollutant. Finally, Tier IV corresponds to source classification codes (SCCs). Each SCC represents a "unique process or function" that produces emissions. For each of the major (i.e., Tier II and Tier III) source categories, the U.S. EPA (Gschwandtner, 1989 and U.S. EPA, 1998) provides documentation that explains the procedures employed to develop the emission estimates, the sources of information required to generate the estimates, and the subcategories are added together to obtain the major source category estimate.

2.4. *Caveats Regarding the Emission Estimates*

When they were published, these data were the best source of information on the trends of emissions. However, the EPA cautioned that the TRENDS estimates were only to be used as indicators of how relative emission levels changed over time, rather than actual measures of emissions of pollutants. *Statistical Methodology for Assigning Emissions to Industries in the United States, Revised Estimates: 1970 to 1997* (U.S. EPA, 2000), uses the U.S. EPA's revised estimates of emissions for 1970 to 1990.

3. EMISSION ESTIMATES FOR INDUSTRIES OF THE INDUSTRIAL SECTOR

3.1. *Sources of Emissions*

The NEA7085.WK3 and SIC7090.WK3 spreadsheets contain estimates of emissions of PM, SO_x, NO_x, VOC, CO, and Pb from the industries that comprise the industrial sector, the electric utilities sector (both public and private), and the gas utilities sector. This study includes emissions from stationary point sources; "area" sources of emissions (i.e., those that cannot be assigned to a specific source) are excluded. The estimates of emissions from the industrial sector consist of process-related sources as well as emissions from the combustion of coal, oil, and natural gas. Emissions from fuel combustion are allocated to industries based on the fuel consumption of each

[15] These exceptions are discussed in section 3.2.1.2.

industry. Fuel combustion emissions from miscellaneous fuels, such as wood and bagasse, are excluded since they could not be assigned to specific industries due to lack of data.

The U.S. EPA (1991a) published estimates of emissions from a variety of sources that are excluded from this study. For example, emissions from the commercial/institutional sector and the residential sector are excluded. In addition, mobile source emissions that occur as a result of activity in the industrial sector are not attributed to individual industries. Hence, all mobile source emissions are excluded from this study. Finally, emissions from solid waste disposal and nonanthropogenic sources such as forest fires and soil erosion dust are also excluded.

The methodology developed in this report is implemented in two spreadsheets. The spreadsheets differ by the level of aggregation (due to the availability of the energy consumption data used to disaggregate the emissions from fuel combustion), and the years for which emission estimates are developed. The first spreadsheet (NEA7085.WK3) contains estimates of emissions for 1970 through 1985. Emissions are assigned to those industries that comprise the industrial sector, the electric utilities sector, and the gas utilities sector. For manufacturing industries, this spreadsheet contains emissions by NEA code which corresponds approximately to the three-digit SIC industry level of disaggregation.

There are four NEA codes in agriculture (three codes are assigned process emissions of at least one pollutant), ten NEA codes in mining (seven codes are assigned process emissions of at least one pollutant), three NEA codes in construction (two codes are assigned process emissions of at least one pollutant), seventy-two NEA codes in manufacturing (thirty-five codes are assigned process emissions of at least one pollutant). Within the industrial sector, forestry and forestry products (NEA 03000) is the only industry assigned neither fuel combustion nor process emissions.

The second spreadsheet (SIC7090.WK3) provides emission estimates for 1970 through 1990 for the twenty two-digit SIC manufacturing industries (SIC 20-39), the electric utilities sector, and the gas utilities sector. The NEA data are used to allocate the emissions from fuel combustion for 1970 to 1985. Using the same methodology as the first spreadsheet, SIC7090.WK3 provides estimates of emissions for the twenty two-digit SIC manufacturing industries. Data from *Derived Annual Estimates of Manufacturing Energy Consumption* (DAEMEC) (See U.S. DOE, 1992 and 1998) are utilized to distribute emissions from fuel combustion among the manufacturing industries for 1986 through 1990.

In both spreadsheets, emissions are attributed directly to the source of emissions and not downstream to the industrial users of the input or to the consumers of the product. This attribution is most important with respect to assigning emissions to the electric utilities sector instead of the industries that consume the electricity. Since both the NEA and the DAEMEC data include estimates of electricity consumption, it is possible for researchers to assign the emissions that result from the generation of electricity to the end users in the economy.

The "Spreadsheet Estimates" section of Table 4 shows the quantity of emissions assigned to industries in this report. The section of Table 4 labeled "Percentage of National Estimates in Spreadsheets" shows the percentage of emissions from all sources assigned to industries in this report. The spreadsheets (NEA7085.WK3 and SIC7090.WK3) contain estimates of emissions from the industrial sector, electric utilities sector, and the gas utilities sector. The spreadsheets exclude emissions from miscellaneous fuels, commercial/institutional, residential sources and mobile sources, and some consumer-related VOC emissions.[16]

According to Table 4, the industrial and electric utilities sectors account for the vast majority of SO_x and PM emissions. In 1970, SO_x emissions from electric utilities and industrial sources represented about 95 percent of total SO_x emissions. For PM, they represented approximately 77 percent of emissions. NO_x is produced by both stationary and mobile sources. VOCs, CO and Pb are more closely associated with mobile sources. As a consequence, the industrial and electric utility sectors account for a smaller percentage of the total emissions for these four pollutants: for NO_x, 48 percent; for VOCs, 31 percent; for CO, 9 percent; and, for Pb, 16 percent.

The manufacturing sector was responsible for 44 percent to 98 percent of emissions from the industrial sector in 1970. Specifically, the manufacturing sector contributed 60 percent of PM emissions, 98 percent of SO_x emissions, 44 percent of NO_x emissions, 71 percent of VOC emissions, 96 percent of CO emissions, and 97 percent of Pb emissions.[17]

3.2. *Methodology for Disaggregating the Emission Estimates*

The procedures employed to allocate emissions from fuel combustion and processes to each industry are described in the remainder of Section 3.2. Section 3.2. also discusses the procedures used to assign emissions to the electric utilities sector and gas utilities sector. Appendix E lists the estimates of emissions for the twenty two-digit SIC manufacturing industries (SIC 20-39) for the six criteria pollutants for 1970 through 1990. The spreadsheets contain the emission estimates produced from applying the following methodology for disaggregating emissions from the industrial sector.

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[16] Emissions from the gas utilities sector, which are derived from the fuel combustion emissions from the industrial sector, are discussed in Section 3.2.5. Consumer-related VOC emissions, which are classified as emissions from industrial processes, are from degreasing, adhesives, solvent extraction processes and other organic solvent uses. Section 3.3.5. provides additional information on these sources of emissions.

[17] For the purpose of determining the percentage of industrial sector emissions assigned to manufacturing industries in Table 4, the following assumptions are made: (1) emissions from the gas utilities sector are assigned to the industrial fuel category, and (2) emissions from consumer-related VOC emissions are assigned to the industrial process category.

Table 4

Emission Estimates in the Spreadsheets and the Percentage of EPA National Estimates of Emissions in the Spreadsheets

		SPREADSHEET ESTIMATE (teragrams)*			PERCENTAGE OF EPA NATIONAL ESTIMATES IN THE SPREADSHEETS**		
POLLUTANT	CATEGORY	1970	1980	1990	1970	1980	1990
SO_x	Industrial Process	7.07	4.23	3.71	24.99	18.08	17.52
	Industrial Fuel	3.98	2.24	2.17	14.07	9.56	10.22
	Electric Utilities Fuel	15.78	15.50	14.24	55.77	66.23	67.16
	Total	26.84	21.96	20.12	94.83	93.87	94.90
NO_x	Industrial Process	0.68	0.67	0.59	3.67	3.23	3.00
	Industrial Fuel	3.77	2.86	3.14	20.38	13.70	16.04
	Electric Utilities Fuel	4.45	6.37	7.28	24.03	30.49	37.13
	Total	8.89	9.91	11.01	48.07	47.41	56.17
VOC	Industrial Process	7.57	7.48	6.44	30.29	33.11	34.45
	Industrial Fuel	0.08	0.06	0.06	0.30	0.26	0.34
	Electric Utilities Fuel	0.03	0.04	0.05	0.11	0.18	0.25
	Total	7.68	7.58	6.55	30.70	33.55	35.03
PM	Industrial Process	10.43	3.29	2.80	56.38	38.75	37.33
	Industrial Fuel	1.41	0.33	0.15	7.60	3.87	2.02
	Electric Utilities Fuel	2.33	0.83	0.42	12.62	9.81	5.58
	Total	14.17	4.46	3.37	76.60	52.43	44.94
CO	Industrial Process	8.09	6.34	4.67	7.98	7.97	7.76
	Industrial Fuel	0.55	0.43	0.46	0.54	0.53	0.77
	Electric Utilities Fuel	0.21	0.29	0.32	0.21	0.37	0.53
	Total	8.86	7.06	5.45	8.73	8.87	9.06
Pb	Industrial Process	23.86	3.58	2.02	11.71	5.08	28.00
	Industrial Fuel	9.10	3.76	0.38	4.46	5.32	5.33
	Electric Utilities Fuel	0.31	0.12	0.06	0.15	0.17	0.84
	Total	33.27	7.46	2.46	16.32	10.56	34.17

* except Pb, which is in thousands of metric tons. One teragram equals one million metric tons, or approximately 1.1 million short tons. One short ton equals two thousand pounds.

** Category totals are from the spreadsheets. Percentages are calculated from totals in U.S. EPA, 1991a, p. 2. Percentages do not total 100 percent of EPA emission estimates because the spreadsheets exclude emissions from miscellaneous fuels, commercial/institutional, residential and mobile sources, and some consumer-related VOC emissions.

3.2.1. Industrial Fuel Combustion Emission Estimates

3.2.1.1. Overview of the Disaggregation Procedure

When developing estimates of fuel combustion emissions for industries, it is assumed that the ratio of fuel consumption to emissions from fuel combustion is identical for all industries. This assumption allows the use of information on fuel consumption by industries to assign emissions from fuel combustion to those industries. The EPA, the NEA, and the DAEMEC data all contain information on physical quantities of energy consumption. However, the energy consumption data employed by the EPA for its estimates of emissions do not include estimates of fuel consumption by specific industries within the industrial sector. The NEA provides data on energy consumption by functional use (i.e., heat and power, transportation), and the DAEMEC provides data on energy consumption for heat and power. Since the EPA, NEA, and DAEMEC data are based on published data sources of energy consumption such as the U.S. DOE's *Coal Distribution, Petroleum Marketing Annual*, and *Cost and Quality of Fuels at Electric Utility Plants*, it was determined that the datasets are comparable, and therefore that NEA and DAEMEC data are used to allocate the EPA estimates of fuel combustion emissions.

Information on fuel consumption for "heat and power" from the NEA and DAEMEC is used to assign emissions from fuel combustion to industries. Emissions from the combustion of a particular fuel are assigned to an industry based on its share of the total consumption of that fuel for "heat and power" by the industrial sector. For example, if an industry consumes 10 percent of all natural gas, then 10 percent of all emissions from natural gas are assigned to that industry.

The source of the energy consumption data used to assign emissions from fuel combustion for 1970 to 1985 is different from the data used to assign emissions between 1986 and 1990. The NEA data series was discontinued in 1985 and its replacement, the DAEMEC, only provides energy consumption data for manufacturing industries. In addition, the estimates of energy consumption developed in this report for 1986 to 1990 for the nonmanufacturing sectors differ from the NEA estimates. The procedural changes necessary to allocate emissions for 1986 to 1990 are discussed after the procedures for allocating emissions for 1970 to 1985.

The NEA and DAEMEC data, which are used to distribute emissions from fuel combustion, consist primarily of purchased energy. However, there are some industries in which energy is produced and consumed at the same establishment. For example, coal is produced and consumed at the same establishment by NEA 07010 and NEA 07020, and natural gas is produced and consumed at the same establishment by NEA 08002 and NEA 08003. This source of fuel is included when distributing emissions that result from coal and natural gas combustion for heat and power.[18]

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[18] The NEA estimate of natural gas produced and consumed at the same establishment in NEA industry 08002 in 1982 differs from the value reported in the *1982 Census of Mineral Industries* (U.S. Department of Commerce, 1985). As a result, the NEA estimates of natural gas produced and consumed at the same establishment in NEA industry 08002 for 1978 to 1985 are re-estimated. This is discussed in Section 3 of *Statistical Methodology for Assigning Emissions to Industries in the United States, Revised Estimates: 1970 to 1997* (U.S. EPA, 2000).

Although the NEA does not provide separate estimates of energy produced and consumed at the same establishment within the manufacturing sector, Price and Wendling (1986, p. 4) state that some fuels consumed for heat and power in the petroleum refining, coke ovens and blast furnaces and steel mills industries are produced and consumed at the same establishment. Price and Wendling indicate that adjustments are made to the data in the NEA for these cases. It is assumed that the differences between the "Total Inputs of Energy for Heat, Power, and Electricity" and "Total Consumption of Offsite-Produced Energy for Heat, Power, and Electricity" tables in the MECS reflect instances when fuels are produced and consumed at the same establishment between 1986 and 1990.

According to the MECS, the petroleum refining industry (SIC 29) accounts for a large percentage of the fuels produced and consumed at the same establishment. The quantities of residual fuel oil, distillate fuel oil, and natural gas consumed for heat and power by the petroleum refining industry from 1986 to 1990 are adjusted so that they are consistent with the NEA data. Section 3.3. of *1970-1997 Revised Estimates* discusses the cases when there are differences between the "Total Inputs of Energy for Heat, Power, and Electricity" and "Total Consumption of Offsite-Produced Energy for Heat, Power, and Electricity" tables in the MECS. According to those two tables, all natural gas produced and consumed by the same establishment within SIC 29 are part of SIC 291 (petroleum refining) (see U.S. DOE, 1988, pp. 25 and 35). Section 3.2.1.3. explains that natural gas consumed by petroleum refining (SIC 291) is excluded when distributing emissions from the consumption of natural gas for heat and power. As a result, information about natural gas consumed and produced at the same establishment in the petroleum refining industry is not used when allocating emissions from the combustion of natural gas for heat and power. Since the MECS estimate of residual fuel oil produced and consumed at the same establishment differs dramatically from the NEA estimate of residual fuel oil produced and consumed at the same establishment, not adjusting the MECS estimate of residual fuel oil consumption leaves it closer to the NEA estimate. Hence, only distillate fuel oil consumption is adjusted for production and consumption by the same establishment in SIC 291.

The methodology employed to assign emissions from fuel combustion assumes that the ratio of fuel consumption to emissions is constant across industries and boilers. Conversations with boiler experts suggest that this simplification may be reasonable since industrial boilers are roughly comparable in size and the regulations affecting them are similar. However, there may be some differences in the efficiency or average sizes of boilers across industries. Data on boiler sizes by industry that would allow a more precise disaggregation are not readily available.[19]

3.2.1.2. Detailed Steps for Disaggregation from 1970 to 1985

When generating industry-level emission estimates, the first step is to develop a concordance between the NEA estimates of fuel consumption by the industrial sector and the estimates of fuel consumption by the industrial sector reported by the TRENDS data. Once the correspondences are established (and extraneous information is subtracted out as discussed below), the TRENDS

[19] This data, although difficult to compile and analyze, is available, at least for certain parts of the country (predominantly for the 1990 base year).

estimates of fuel consumption by the industrial sector are assumed to equal the NEA estimates of energy consumption by the industries of the industrial sector.

After developing the mapping, the second step is to make the appropriate adjustments to the data so that the energy consumption estimates of the NEA matches estimates of energy consumption employed by the TRENDS methodology. Two adjustments are necessary to make the NEA estimates of energy consumption by the industrial sector comparable to the estimates of energy consumption used by the TRENDS methodology when estimating emissions from fuel combustion. The first adjustment is to include only fuel consumed for "heat and power" according to the NEA.[20] The second adjustment involves deleting from the NEA estimates of fuel consumed for "heat and power" any fuel whose emissions are treated by the TRENDS methodology as process emissions. Since the emissions that occur as a result of certain fuel-industry combinations are treated by the TRENDS methodology as process emissions, failure to make these adjustments results in some emissions being "double counted" (i.e., emissions that result from the consumption of those fuels would be assigned twice to those industries). Hence, the consumption of the following fuels by cement plants, petroleum refineries, and steel mills are deleted from the NEA estimates of fuel consumed for heat and power:[21]

- Bituminous coal and lignite consumption by cement plants and by lime plants. (For documentation that these categories are not in the TRENDS methodology combustion emissions, see the page labeled 60, Section 3.7.3.1, Gschwandtner, 1989);[22]

[20] Energy consumption for "heat and power" is assigned functional use code 10 in the NEA data and constitutes the majority of energy consumption in the NEA (Price and Wendling, 1986).

[21] The NEA reported that fuels were consumed for "heat and power" by the following combinations of fuels and NEA sectors: coal (cement - NEA 36010 and lime -36990), residual fuel oil (petroleum refining - NEA 31011, cement - NEA 36010, and blast furnaces - NEA 37012), distillate fuel oil (petroleum refining - NEA 31011, and cement - NEA 36010), and natural gas (petroleum refining - NEA 31011, glass - NEA 35000, cement - NEA 36010, and blast furnaces - NEA 37012). These are the fuel-industry combinations whose fuel consumption for "heat and power" are adjusted for the purpose of distributing emissions from fuel combustion.

[22] The EPA data source for coal consumption excludes coke oven plants. According to the NEA, coke oven plants (NEA 37011) do not consume coal for heat and power. This is assumed to be true for 1986 to 1990. Lime (SIC 3274) is the principal consumer of coal for "heat and power" in 1991 and 1994 (see U.S. DOE 1994, p. 61 and 1997, p. 61) by the industries that belong to NEA 36990.

- Residual oil consumption by cement plants (subtract two-thirds of the consumption), by petroleum refineries, and by steel mills (specifically blast furnaces). (See the page labeled 79, Section 3.8.3.1, Gschwandtner, 1989);[23]

- Distillate oil consumption by cement plants (subtract one-third of the consumption) and by petroleum refineries (See the page labeled 79, Section 3.8.3.1, and the page labeled 87, Section 3.9.3.1, Gschwandtner, 1989); and[24]

- Natural gas consumption by cement plants and by petroleum refineries, by iron and steel industry and by glass manufacturing (See the page labeled 94, Section 3.10.3.1, Gschwandtner, 1989).

Once these adjustments are made, it is assumed that the EPA and NEA data are compatible.[25] The remaining fuel consumed for "heat and power" in the NEA data are used to assign fuel combustion emissions to the industries of the industrial sector.[26]

After these adjustments are made, the next step is to calculate each industry's share of the fuel consumed (in physical units) for "heat and power" by the industrial sector. These shares are used to assign emissions from fuel combustion among the industries of the industrial sector. This process is repeated for each fuel type. The emissions from each fuel type are added to determine total emissions from fuel combustion by each industry.

3.2.1.3. Disaggregation from 1986 to 1990

The NEA data ceased to be updated after 1985. The triennial MECS was first conducted by the U.S. DOE (1988) in 1985. The MECS was subsequently conducted in 1988, 1991, and 1994 (U.S. DOE, 1991, 1994, 1997).

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[23]According to the U.S. DOE (1988, pp. 24 and 31), in 1985 all residual oil consumed by cement plants is for "heat and power." This is also true in 1988 (see U.S. DOE, pp. 25 and 28) and 1991 (see U.S. DOE 1994, pp. 55 and 61).

[24]According to the U.S. DOE (1988, pp. 24 and 31), in 1985 virtually all distillate fuel oil consumed by cement plants is for "heat and power." This is also true in 1988 (see U.S. DOE, pp. 25 and 28) and 1991 (see U.S. DOE, 1994, pp. 55 and 61).

[25] These adjustments are also described in *National Air Pollutant Emission Trends Procedures Document, 1900-1996 Projections 1999-2010* (U.S. EPA, 1998, pp. 3-35, 3-38, 3-39, and 3-43). Residual fuel oil and natural gas consumed by Blast furnaces (NEA 37012) is employed as a proxy for the residual fuel oil and natural gas consumed by the "raw steel" industry (see U.S. EPA, 1998, pp. 3-39 and 3-43).

[26] The concordance among the twenty two-digit SIC manufacturing industries and the NEA codes is shown in Appendix B. Appendix C lists the names and SIC equivalents of the NEA codes that comprise the industrial sector.

The energy consumption data for 1985, 1988, 1991, and 1994 reported in the DAEMEC (U.S. DOE, 1992 and 1998) are taken from the "Total Consumption of Offsite-Produced Energy for Heat, Power, and Electricity Generation" tables in the MECS. These data are comparable to data found in the *Annual Survey of Manufactures* (ASM). The ASM data are the basis of the pre-MECS estimates in the *Derived Annual Estimates of Manufacturing Energy Consumption* (DAEMEC) and the NEA data for the manufacturing industries (U.S. DOE, 1992, pp. 3-4). The discrepancies between the NEA and DAEMEC data are discussed in Section 3 of *Statistical Methodology for Assigning Emissions to Industries in the United States, Revised Estimates: 1970 to 1997*.[27]

The DAEMEC provides estimates of energy consumption (in Btu) for 1974 to 1994; however, only the data for 1974 to 1988 are reported in physical units. As a result, the DAEMEC data (in Btu) are used to assign fuel combustion emissions between 1986 and 1990. For each type of fuel consumed for heat and power, the NEA data use the same energy conversion factor for all industries. However, there are some differences between the energy conversion factors for coal and natural gas employed by the DAEMEC and the sources of information about energy consumption by the nonmanufacturing portion of the industrial sector from 1986 to 1990. However, these discrepancies do not appear to dramatically affect the assignment of emissions.[28]

Since the MECS data are more aggregated than the NEA data, the adjustments to the energy consumption data described in section 3.2.1.2. are modified for 1986 to 1990. Using Appendix C and the information in Section 3.2.1.2., energy consumed for "heat and power" by the following combinations of fuels and SIC codes are subtracted before assigning fuel combustion emissions to industries: coal (cement - SIC 3241 and lime - SIC 3274), residual fuel oil (petroleum refining - SIC 2911, cement - SIC 3241 - subtract two-thirds of the consumption, and blast furnaces - SIC 3312), distillate fuel oil (petroleum refining - SIC 2911, and cement - SIC 3241 - subtract one-third of the consumption), and natural gas (petroleum refining - SIC 2911, glass - SIC 321, 322, and 323, and cement - SIC 3241, and blast furnaces - SIC 3312). For 1986, 1987, 1989, and 1990 (i.e., the years between the MECS data), fuel consumption by the various three-digit and four-digit SIC industries are derived using information from the 1985, 1988 and 1991 MECS and the two-way indexing method (see U.S. DOE, 1992, pp. 6-8 and Appendix D of *1970-1997 Revised Estimates*).

Due to limitations of the MECS data, there are four fuel-industry combinations for which the adjustments described in the preceding paragraph are not possible. First, only the 1994 MECS lists fuel consumption by SIC 331. In the 1985 and 1988 MECS, energy consumption is reported for only SIC 3312. In the 1991 MECS, energy consumption by SIC industries 3312 and 3313 are reported. According to the 1994 MECS, SIC 3312 accounts for virtually all residual fuel oil consumption by SIC 331 and more than 90 percent of the natural gas consumption of SIC 331 (U.S.

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[27] Throughout the remainder of this report, *Statistical Methodology for Assigning Emissions to Industries in the United States, Revised Estimates: 1970 to 1997* is referred to as *1970-1997 Revised Estimates*.

[28] The shares of coal, residual fuel oil, distillate fuel oil, and natural gas consumption assigned to industries in Sheets Z, AA, AB, and AC of SIC7090.WK3 do not appear to experience a dramatic change between 1985 (NEA data) and 1986 (DAEMEC data).

DOE 1997, p. 73). In the 1985 MECS, SIC 3312 accounts for virtually the same share of the consumption of residual fuel oil and natural gas by SIC 33 as does SIC 331 in the NEA for 1985. Hence, between 1986 and 1990 the residual fuel oil and natural gas consumption of only SIC 3312 is subtracted from the residual fuel oil and natural gas consumption of SIC 33.

Second, the 1985 MECS and 1988 MECS do not list estimates of natural gas consumption for SIC 321, SIC 322 or SIC 323. Within SIC 321, SIC 322, and SIC 323, estimates of natural gas consumption are reported for only SIC 3211, SIC 3221, and SIC 3229 in 1991 and 1994 MECS. Hence, it is assumed that the share (0.443) of the natural gas consumption of SIC 32 by SIC 321, SIC 322, and SIC 323 in 1985, which is reported by the NEA, is a reasonable estimate for 1986 to 1990.

Third, the MECS did not publish data on the consumption of residual fuel oil by the cement industry (SIC 3241) until 1991. Hence, the two-way indexing method (see Appendix D of *1970-1997 Emissions*) uses the 1985 NEA estimate of the share (0.1899) of the residual fuel oil consumption of SIC 32 that is accounted for by SIC 3241 and the estimate in the 1991 MECS to estimate the share of residual fuel oil consumption of SIC 32 that is accounted for by SIC 3241 from 1986 to 1990.

Finally, the MECS did not publish estimates of coal consumption by SIC 3274 until 1991. The 1985 and 1988 MECS did publish estimates of coal consumption by SIC 3241. According to the NEA, in 1985 these industries accounted for 99.92 percent of the coal consumed by SIC 32. Since they account for almost all coal consumed by SIC 32, for the purpose of adjusting the coal consumption of SIC 32 they are treated as a single industry. Hence, the two-way indexing method uses the 1985 NEA and the 1991 MECS estimates of their share of the coal consumption of SIC 32 to estimate their share of coal consumption of SIC 32 from 1986 to 1990.

Unlike the NEA, the MECS includes only energy consumed by the manufacturing sector. With some modifications, fuel consumption by the nonmanufacturing portion of the industrial sector is estimated for 1986 to 1990 using many of the same data sources as the NEA data. However, the estimates of energy consumption by the nonmanufacturing industries for 1970 to 1985 and 1986 to 1990 are not directly comparable. This is due to the assignment in the NEA of selected industries in the mining sector to the construction sector. Section 3.1. and Section 3.2. of *1970-1997 Revised Estimates* describe the procedures employed to estimate energy consumption by the manufacturing and nonmanufacturing industries for 1986 to 1997.

3.2.2. Industrial Process Emission Estimates

When assigning process emissions to industries, a concordance is established between the NEA codes, the SIC codes, and the source categories of process emissions in TRENDS. Appendix A specifies the concordance between the SIC codes, the NEA codes, and the categories of process emissions. When necessary, the *Standard Industrial Classification Manual* (Executive Office of the President, Office of Management and Budget, 1987) is used to match the SIC and NEA codes with the categories of process emissions. Some categories of industrial process emissions in the TRENDS methodology were assigned SIC codes in the *1940-1990 NAPEE*. Appendix D contains a discussion of the cases in which the assignment of process emissions in this report differs from the assignments made in the *1940-1990 NAPEE* (U.S. EPA 1991a).

3.2.3. Estimates of Total Emissions

The sum of fuel combustion emissions and process emissions for each NEA code yields its total emissions for 1970 to 1985. Total emissions for 1986 to 1990 are the combined emissions from fuel combustion and processes by the twenty two-digit SIC industries of the manufacturing sector.

3.2.4. Electric Services (Utilities) Estimates

In the TRENDS methodology, there are separate entries for emissions associated with the coal, fuel oil, and natural gas combustion of the Electric Utilities source category. In this report, the combined emissions from the combustion of these three fuels constitute the estimate of emissions from the electric utilities sector.

3.2.5. Gas Production and Distribution (Utilities) Estimates

In the TRENDS methodology, there are separate entries for emissions associated with the coal, fuel oil, and natural gas combustion of the industrial sector. In this report, all emissions from the combustion of coal and fuel oil by the industrial sector are assigned to industries. Emissions that result from natural gas fuel combustion by the industrial sector are divided into emissions from "boilers" and emissions from "gas pipelines and plants." Natural gas emissions from "boilers" are assigned to industries in the industrial sector based on the amount of natural gas consumed for heat and power by the respective industries. Natural gas emissions from "gas pipelines and plants" are assigned to the gas utilities sector.

3.3. *Considerations in Excluding Certain Categories of Emissions*

The remainder of this section describes which categories of emissions are not assigned to industries in this report.

3.3.1. Miscellaneous Fuel Consumption from all Sectors

Emissions from miscellaneous fuels are not assigned to industries because the NEA data contains limited information on industrial consumption of miscellaneous fuels. The largest use of miscellaneous fuels in the TRENDS methodology is the residential use of wood.

3.3.2. Commercial/Institutional

In the TRENDS methodology, there are separate entries for emissions associated with coal, fuel oil, and natural gas combustion of the Commercial/Institutional category. The Commercial/Institutional category includes the communications, restaurants, retail trade, wholesale trade, water and sanitation, and finance and insurance sectors. These emissions are excluded from this study because there is no relevant energy consumption data to allocate emissions among individual industries within the commercial/institutional sector. In 1970, the commercial/institutional sector represented 3 percent of all emissions for SO_x, 1 percent for PM, 2 percent for NO_x, and 0 percent for VOC, CO and Pb.

3.3.3. Residential

Residential emissions are excluded since the spreadsheets contain emissions from production, not consumption, activities. In 1970, residential emissions accounted for 3 percent for PM, CO, and NO_x, 2 percent for SO_x and VOC, and 0 percent for Pb.

3.3.4. Mobile Sources

Mobile source emissions are excluded from the spreadsheets. Industrial emissions, therefore, do not include emissions from the industrial use of cars, trucks, or mobile equipment.

3.3.5. Consumer-related VOC emissions

Certain consumer-related VOC emissions are excluded from the spreadsheets. These are VOC emissions from degreasing, adhesives, solvent extraction processes and other organic solvent uses. Since they are emitted during use of the product, it would be inconsistent to assign them upstream to the chemical industry. In 1970 about 15 percent of VOC emissions were consumer-related versus roughly 9 percent in 1990. These emissions are contained in the TRENDS estimates but are excluded from the spreadsheets.

3.4. *Weaknesses of the Disaggregation Procedure*

The process emissions are assigned to the industry that is the primary producer of the output of the production process. The existence of secondary production (i.e., output that is primary to another industry) by an industry results in some errors being introduced in the assignment of process emissions.

The crucial assumption in disaggregating the emissions estimate is the requirement that the ratio of fuel consumption to emissions from fuel combustion is constant across industries and types of boilers. If this assumption is erroneous, then there are errors in the assignment of emissions from fuel combustion.

4. OVERVIEW OF THIS REPORT

This report described the methodology uses to develop emission estimates of criteria air pollutants from 1970 to 1990 for manufacturing industries and selected nonmanufacturing industries. These spreadsheets will be useful to researchers interested in developing models that require a time series of emissions for individual industries.

The first spreadsheet (NEA7085.WK3) consists of estimates of emissions for 1970 to 1985 for those NEA codes (i.e., industries) that belong to the industrial sector, the electric utilities sector, and the gas utilities sector. The industrial sector consists of four industries in agriculture, ten industries in mining, three industries in construction, seventy-two industries in manufacturing.

The primary data source for energy consumption after 1985 is more aggregated than the NEA data and only reports energy consumption by manufacturing. As a result, the second

spreadsheet (SIC7090.WK3) contains emission estimates from 1970 to 1990 for the twenty two-digit SIC manufacturing industries (SIC 20-39), the electric utilities sector, and the gas utilities sector.

After the *1940-1990 NAPEE* was released, the U.S. EPA changed the methodology that it uses to estimate emissions. For its estimates of emissions after 1984, the "top-down" methodology, which was the basis of the estimates of emissions used in this report, was replaced by a modified "bottom-up" methodology. In addition, the U.S. EPA revised its estimates of emissions for 1970 to 1984. *Statistical Methodology for Assigning Emissions to Industries in the United States, Revised Estimates: 1970 to 1997* (U.S. EPA, 2000) applies many of the procedures developed in this report when assigning emissions to the twenty two-digit SIC manufacturing industries for 1970 to 1997.

BIBLIOGRAPHY

Executive Office of the President, Office of Management and Budget (1972), *Standard Industrial Classification Manual, 1972*, U.S. Government Printing Office, Washington, DC.

Executive Office of the President, Office of Management and Budget (1987), *Standard Industrial Classification Manual, 1987*, National Technical Information Service, Springfield, Virginia, PB-87-100012. (The following URLs have information on the 1987 SIC codes: (http://www.osha.gov/oshstats/sicser.html and http://www.lib.virginia.edu/socsci/sic.html)

Executive Office of the President, Office of Management and Budget (1998), *North American Industrial Classification System: United States, 1997*, National Technical Information Service, Springfield, Virginia, PB98-127293.

Gschwandtner, Gerhard (1989), *The Procedures Document for the Development Of National Emissions Trends Report*, E.H. Pechan and Associates, Inc. Report prepared for the Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency. December Revision.

Gschwandtner, Gerhard and Janice K. Wagner (1988), *Historic Emissions of Volatile Organic Compounds In the United States from 1900 to 1985*. E.H. Pechan and Associates, Inc. Report prepared for the Office of Research and Development, U.S. Environmental Protection Agency and the National Acid Precipitation Assessment Program, EPA-600-7-88-008a, Springfield, Va: National Technical Information Service (NTIS PB88-208723).

Jensen, Helle and Ole Pedersen (1998), *Danish NAMEA, 1980-1992*, Statistics Denmark and Eurostat.

Keuning, Steven J. and Mark DeHann (1998), "Netherlands: What's in a NAMEA? Recent Results," in *Environmental Accounting in Theory and Practice*, Vol. 11 of Economy and Environment series, eds. Kimio Uno and Peter Bartelmus, pp. 143-156, Boston: Kluwer Academic Publishers.

National Acid Precipitation Assessment Program (1993), *1992 Report to Congress*, Washington, D.C.: National Acid Precipitation Assessment Program.

Nestor, Deborah Vaughn and Carl A. Pasurka, Jr. (1995), "Environment-Economic Accounting and Indicators of the Economic Importance of Environmental Protection Activities," *Review of Income and Wealth*, 41, No. 3 (September), 265-287.

Nestor, Deborah Vaughn and Carl A. Pasurka, Jr. (1998), "USA: Environmental Protection Activities and Their Consequences," in *Environmental Accounting in Theory and Practice*, Vol. 11 of Economy and Environment series, eds. Kimio Uno and Peter Bartelmus, pp. 131-142, Boston: Kluwer Academic Publishers.

Nordhaus, William D. and Edward C. Kokklenberg, eds. (1999), *Nature's Numbers: Expanding the National Economic Accounts to Include the Environment*, Washington, D.C.: National Academy Press (www.nap.edu/books/0309071518/html/).

Price, Lori H. and Robert M. Wendling (1986), "National Energy Accounts: An Overview," Capital, Energy and Productivity Studies Division, Office of Business Analysis, U.S. Department of Commerce, Draft, March 1986.

Stahmer, C., M. Kuhn, and N. Baum (1998), "Physical Input-Output Tables for Germany, 1990," Eurostat Working Paper No. 2/1998/B/1, European Commission.

Statistical Office of the European Communities (1999), *Pilot Studies on NAMEAs for Air Emissions with a Comparison at European Level*, Theme 2, Economy and Finance, Luxembourg: Office for Official Publications of the European Communities.

United Nations (1993), Handbook of National Accounting, Studies in Methods, Series F, No. 61, *Integrated Environmental and Economic Accounting*, Interim Version, United Nations: New York. (ST/ESA/STAT/SER.F/61, UN publication, Sales No. E.93.XVII.12).

U.S. Department of Commerce, Bureau of the Census (1985), *1982 Census of Mineral Industries*, Washington, DC: U.S. Government Printing Office.

U.S. Department of Commerce, Bureau of Economic Analysis (1994a), "Integrated and Environmental Satellite Accounts," *Survey of Current Business*, 74, No. 4 (April), 33-49. (see "NIPA Related Articles" at the following URL: http://www.bea.doc.gov/bea/an1.htm for PDF and HTML versions of the article)

U.S. Department of Commerce, Bureau of Economic Analysis (1994b), "Accounting for Mineral Resources: Issues and BEA's Initial Estimates," *Survey of Current Business*, 74, No. 4 (April), 50-72. (see "NIPA Related Articles" at the following URL: http://www.bea.doc.gov/bea/an1.htm for PDF and HTML versions of the article)

U.S. Department of Commerce, Bureau of the Census (1996), *Pollution Abatement Costs and Expenditures: 1994*, Current Industrial Reports, MA200, U.S. Government Printing Office: Washington, D.C. (http://www.census.gov/prod/2/manmin/ma200x94.pdf)

U.S. Department of Energy, Energy Information Administration (1988), *1985 Manufacturing Energy Consumption Survey*, DOE/EIA-0512(85), Washington, D.C. (HTML file of "Derived Annual Estimates of Manufacturing Consumption 1974-1988" is located at the following URL: (http://www.eia.doe.gov/emeu/consumption)

U.S. Department of Energy, Energy Information Administration (1991), *1988 Manufacturing Energy Consumption Survey*, DOE/EIA-0512(88), Washington, D.C. (HTML, PDF, and WK1 files are located at the following URL: (http://www.eia.doe.gov/emeu/consumption)

U.S. Department of Energy, Energy Information Administration (1992), *Derived Annual Estimates of Manufacturing Energy Consumption, 1974-1988*, DOE/EIA-0555(92)/3, Washington, D.C. (HTML, PDF, and WK1 files are located at the following URL: http://www.eia.doe.gov/emeu/consumption)

U.S. Department of Energy, Energy Information Administration (1994), *1991 Manufacturing Energy Consumption Survey*, DOE/EIA-0512(91), Washington, D.C. (HTML, PDF, and WK1 files are located at the following URL: (http://www.eia.doe.gov/emeu/consumption)

U.S. Department of Energy, Energy Information Administration (1997), *1994 Manufacturing Energy Consumption Survey*, DOE/EIA-0512(94), Washington, D.C.

U.S. Department of Energy, Energy Information Administration (1998), *Derived Annual Estimates of Manufacturing Energy Consumption 1988-1994*, Energy Consumption Series, it was last modified August 14, 1998 (http://www.eia.doe.gov/emeu/consumption/)

U.S. Environmental Protection Agency, Office of Air and Radiation, Office of Air Quality Planning and Standards (1985), *Compilation of Air Pollutant Emission Factors*, Volumes I and II, AP-42, Fourth Edition, PB86-124906, Springfield, Va: National Technical Information Service.

U.S. Environmental Protection Agency, Office of Air and Radiation, Office of Air Quality Planning and Standards (1990), *AIRS Facility Subsystem Source Classification Codes and Emission Factor Listing for Criteria Air Pollutants*, EPA 450/4-90-003.

U.S. Environmental Protection Agency, Office of Air and Radiation, Office of Air Quality Planning and Standards (1991a), *National Air Pollutant Emission Estimates, 1940-1990*, EPA-450/4-91-026.

U.S. Environmental Protection Agency, Office of Air and Radiation, Office of Air Quality Planning and Standards (1991b), *National Air Quality and Emission Trends Report, 1990*, EPA-450/4-91-023.

U.S. Environmental Protection Agency, Office of Air and Radiation, Office of Air Quality Planning and Standards (1993), *Regional Interim Emission Inventories (1987 - 1991), Volume I: Development Methodologies*, EPA-454/R-93-021a.

U.S. Environmental Protection Agency, Office of Research and Development (1994), *Comparison of the 1985 NAPAP Emissions Inventory with the 1985 EPA TRENDS Estimate for Industrial SO_2 Sources*, TRC Environmental Corp., Chapel Hill, NC. EPA-600/R-94-012, Springfield, Va: National Technical Information Service (NTIS PB94-152220).

U.S. Environmental Protection Agency, Office of Policy, Planning, and Evaluation (1995a), *The U.S. Environmental Protection Industry: A Proposed Framework for Assessment*. (See "Report Inventory" at the following URL: http://www.epa.gov/docs/oppe/eaed/eedhmpg.htm)

U.S. Environmental Protection Agency, Office of Policy, Planning, and Evaluation (1995b), *The U.S. Environmental Protection Industry: The Technical Document*. (See "Report Inventory" at the following URL: http://www.epa.gov/docs/oppe/eaed/eedhmpg.htm)

U.S. Environmental Protection Agency, Office of Air and Radiation, Office of Air Quality Planning and Standards (1995c), *National Air Pollutant Emission Trends, 1900-1994*, EPA-454/R-95-011.

U.S. Environmental Protection Agency, Office of Air and Radiation, Office of Air Quality Planning and Standards (1998), *National Air Pollutant Emission Trends Procedures Document, 1900-1996 Projections 1999-2010*, EPA 454/R-98-008. (http://www.epa.gov/ttn/chief/ei_data.html#ETDP).

U.S. Environmental Protection Agency, Office of Policy, Economics and Innovation, National Center for Environmental Economics (2001), *Statistical Methodology for Assigning Emissions to Industries in the United States, Revised Estimates: 1970 to 1997*, EPA 240-R-01-003. (http://www.epa.gov/economics/)

Vogan, Christine (1996), "Pollution Abatement and Control Expenditures, 1972-94," *Survey of Current Business*, 76, No. 9 (September), 48-67. (See "NIPA Related Articles" at the following URL: http://www.bea.doc.gov/bea/an1.htm for PDF and HTML versions of the article)

APPENDIX A

CONCORDANCE AMONG TRENDS EMISSION SOURCE CATEGORIES, SIC CODES AND NEA CODES (BY POLLUTANT)

Table A-1

Concordance Between the TRENDS Emission Source Categories, SIC Codes, and NEA Codes for Emissions of Particulate Matter

TRENDS EMISSION SOURCE CATEGORY	SIC	NEA
IRON AND STEEL INDUSTRY		
Coke		
By-Product	33	37011
Coal Prep/Coke Handling	33	37011
Blast Furnace	33	37012
Sintering		
Windbox	33	37990
Discharge	33	37990
Sinter-Fugitive	33	37990
Open Hearth		
Open Hearth-Stack	33	37990
Open Hearth-Fugitive	33	37990
Basic Oxygen		
BOF-Stack	33	37012
BOF-Fugitive	33	37012
Electric Arc		
EAF-Stack	33	37990
EAF-Fugitive	33	37990
Slag		
Blast Furnace	33	37990
Steel Furnace	33	37990
Scarfing	33	37990
Teeming	33	37990
Soaking Pits	33	37990
Reheat Furnaces	33	37990
Open Dust	33	37990
Ore Screening	33	37990

Table A-1 (continued)

TRENDS EMISSION SOURCE CATEGORY	SIC	NEA
PRIMARY METALS INDUSTRY		
Aluminum		
Calcining of Hydroxide	33	38040
HSS-Stack	33	38040
HSS-Fugitive	33	38040
VSS-Stack	33	38040
VSS-Fugitive	33	38040
Prebake-Stack	33	38040
Prebake-Fugitive	33	38040
Anode Baking	33	38040
Material Handling	33	38040
Copper		
Roasting	33	38990
Smelting	33	38990
Converting	33	38990
Fugitive	33	38990
Zinc		
Roasting	33	38990
Sintering	33	38990
Electrolytic	33	38990
Horizontal Retort	33	38990
Vertical Retort	33	38990
Fugitive	33	38990
Lead		
Sintering	33	38990
Blast Furnace	33	38990
Reverberatory Furnace	33	38990
Fugitive	33	38990
Ferroalloys		
Fe-Si	33	37990
Si-Mn	33	37990
Fe-Mn Electric Furnace	33	37990
Fe-Mn Blast Furnace	33	37990
Si Metal	33	37990
Other Ferroalloys	33	37990
Fe-alloy Material Handling	33	37990

Table A-1 (continued)

TRENDS EMISSION SOURCE CATEGORY	SIC	NEA
SECONDARY METALS INDUSTRY		
Grey Iron Foundries		
Cupola	33	37990
Electric Induction	33	37990
Fugitive	33	37990
Steel Foundries		
Electric Arc	33	37990
Fugitive	33	37990
Aluminum		
Sweating	33	38040
Refining	33	38040
Fluxing	33	38040
Fugitive	33	38040
Lead		
Pot Furnace	33	38990
Reverberatory Furnace	33	38990
Blast Furnace	33	38990
Fugitive	33	38990
Copper		
Wire Burning	33	38990
Brass & Bronze Casting	33	38990
Smelting	33	38990
Fugitive	33	38990
MINERAL PRODUCTS INDUSTRY		
Cement Manufacturing		
Kilns	32	36010
Grinders	32	36010
Fugitive	32	36010
Asphalt Batching		
Dryers	29	31990
Fugitive	29	31990

Table A-1 (continued)

TRENDS EMISSION SOURCE CATEGORY	SIC	NEA
MINERAL PRODUCTS INDUSTRY (*continued*)		
Asphalt Roofing		
Blowing	29	31990
Felt Saturation	29	31990
Bricks	32	36990
Clay Sintering	32	36990
Concrete Batching	32	36990
Fiber Glass		
Furnace	32	35000
Forming	32	35000
Curing	32	35000
Glass	32	35000
Gypsum Manufacturing		
Dryer	32	36990
Calciner	32	36990
Lime Manufacturing		
Kilns	32	36990
Fugitive	32	36990
CHEMICAL INDUSTRY		
Sulfuric Acid	28	27010
Calcium Carbide	28	27010
Carbon Black Production		
Oil Process	28	27040
Gas Process	28	27040
Petrochemicals		
Phthalic Anhydride	28	27010
Polyethylene	28	27010
PVC	28	27010
Polypropylene	28	27010

Table A-1 (continued)

TRENDS EMISSION SOURCE CATEGORY	SIC	NEA
CHEMICAL INDUSTRY (*continued*)		
Charcoal	28	27040
Fertilizers		
Ammonium Nitrate	28	27020
Diammonium Phosphate	28	27020
Urea	28	27020
Rock Pulverization	28	27020
Soap & Detergent	28	29000
MISCELLANEOUS PROCESS		
Pulp and Paper		
Kraft	26	24020
Sulfite	26	24020
Semi-Chemical (Paper)		
Recovery Furnace	26	24020
Fluid bed Reactor	26	24020
Plywood	24	20990
Lumber	24	20990
Petroleum Refining		
F.C.C.	29	31011
T.C.C.	29	31011
Process Heaters		
Oil	29	31011
Gas	29	31011
AGRICULTURAL INDUSTRIES		
Cotton Ginning	7	04000
Cattle Feedlots	2	01000
Alfalfa Dehydrators	20	14000
Country Elevators	7	02000
Terminal Elevators	7	02000
Feed Mills	20	14000
Grain Milling		
Wheat	20	14000
Corn-Dry	20	14000
Corn-Wet	20	14000
Rice	20	14000
Soybeans	20	14000

Table A-1 (continued)

TRENDS EMISSION SOURCE CATEGORY	SIC	NEA
MINING OPERATIONS		
Iron Ore Mining	10	05000
Taconite Processing	10	05000
Bauxite Crushing	10	06002
Copper Ore Crushing	10	06002
Zinc Ore Crushing	10	06002
Lead Ore Crushing	10	06002
Coal Mining		
Surface Mining	12	07020
Coal Handling	12	07020
Thermal Dryers	12	07020
Pneumatic Dryers	12	07020
Sand & Gravel	14	09000
Stone & Rock Crushing	14	09000
Phosphate Rock		
Drying or Calcining	14	10000
Grinding	14	10000
Material Handling	14	10000
Clays	14	09000
Potash	14	10000

Table A-2

Concordance Between the TRENDS Emission Source Categories, SIC Codes, and NEA Codes for Emissions of Sulfur Oxides

TRENDS EMISSION SOURCE CATEGORY	SIC	NEA
NON-FERROUS SMELTERS		
Copper		
Roasting	33	38990
Smelting	33	38990
Converting	33	38990
Zinc Roasting	33	38990
Lead Processing	33	38990
OTHER INDUSTRIAL PROCESSES		
Kraft Pulp Prod. + Sulfite	26	24020
Sulfuric Acid	28	27010
Carbon Black	28	27040
Sulfur Recovery Plants		
Refineries	28	27010
Natural Gas Fields	28	27010
Petroleum Refineries		
F.C.C.	29	31011
T.C.C.	29	31011
Flares	29	31011
Process Heaters		
Oil	29	31011
Gas	29	31011
Iron & Steel		
Coking	33	37011
Sintering	33	37990
Open Hearth	33	37012
Roll & Finish	33	37990
Primary Aluminum	33	38040
Secondary Lead		
Reverberatory Furnace	33	38990
Blast Furnace	33	38990
Cement Manufacturing	32	36010
Glass Manufacturing	32	35000
Lime Processing	32	36990

Table A-3

Concordance Between the TRENDS Emission Source Categories, SIC Codes, and NEA Codes for Emissions of Nitrogen Oxides

TRENDS EMISSION SOURCE CATEGORY	SIC	NEA
INDUSTRIAL PROCESSES		
Petroleum Refineries		
F.C.C.	29	31011
T.C.C.	29	31011
Flares	29	31011
Process Heaters		
Oil	29	31011
Gas	29	31011
Petrochemicals		
Acrylonitrile	28	27010
Adipic Acid	28	27010
Adiponitrile	28	27010
Ammonia	28	29000
Nitric Acid	28	27020
Iron & Steel		
Open Hearth	33	37012
Roll & Finish	33	37012
Kraft Pulp	26	24020
Cement Manufacturing	32	36010
Glass Manufacturing	32	35000
Lime	32	36990
Charcoal	28	27040

Table A-4

Concordance Between the TRENDS Emission Source Categories, SIC Codes, and NEA Codes for Emissions of VOCs

TRENDS EMISSION SOURCE CATEGORY	SIC	NEA
MISCELLANEOUS INDUSTRIAL PROCESSES		
Plastics Manufacture		
HD Polyethylene	28	28010
LD Polyethylene	28	28010
Polypropylene	28	28010
Polystyrene	28	28010
Polyvinyl Chloride	28	28010
Others	28	28010
Fabrication	28	28010
Misc. Chemical Products		
Synthetic Fibers	28	28990
Pharmaceuticals	28	29000
Paint	28	30000
Synthetic Rubber	28	28020
Ammonia	28	29000
Carbon Black		
Oil Process	28	27040
Gas Process	28	27040
Charcoal	28	27040
Other Processes		
Bakeries	20	14000
Fermentation	20	14000
Vegetable Oil	20	14000
Fabric Scouring	22	16000
Tires	30	32000
Glass Manufacturing	32	35000
By-Product Coke	33	37011
Sintering	33	37990
Waste Solvent Recovery	NA	NA
Organic Solvent	NA	NA
Adhesives	NA	NA
Degreasing	NA	NA
Dry Cleaning	NA	NA
Graphic Arts	27	26000
Solvent Extraction	NA	NA

Table A-4 (continued)

TRENDS EMISSION SOURCE CATEGORY	SIC	NEA
PETROLEUM REFINERY PROCESS OPERATIONS		
Refinery Operations		
F.C.C.	29	31011
T.C.C.	29	31011
Process Heaters		
Oil	29	31011
Gas	29	31011
Compressors	29	31011
Blow Down Systems	29	31011
Process Drains	29	31011
Vacuum Jets	29	31011
Cooling Towers	29	31011
Asphalt Blowing	29	31011
Miscellaneous	29	31011
MANUFACTURER OF PETROCHEMICALS		
Acetic Acid	28	27010
Acrylic Acid	28	28010
Acrylonitrile	28	27010
Adiponitrile	28	27010
Benzene	28	27010
Butadiene & Butylene Fraction	28	28010
1,3-Butadiene	28	28010
Caprolactum	28	27010
Chlorobenzene	28	27010
Chloromethane	28	27010
Cyclohexanone	28	27010
Cumene	28	27010
Dimethyl Terephthalate	28	27010
Ethyl Benzene	28	27010
Ethylene	28	27010
Ethylene Dichloride	28	27010
Ethylene Glycol	28	27010
Ethylene Oxide	28	27010
Formaldehyde	28	27010
Linear Alkylbenzene	28	27010

Table A-4 (continued)

TRENDS EMISSION SOURCE CATEGORY	SIC	NEA
MANUFACTURER OF PETROCHEMICALS (*continued*)		
Maleic Anhydride	28	27010
Methanol	28	27010
Methyl Methacrylate	28	27010
Nitrobenzene	28	27010
Perchlorethylene	28	27010
Phenol	28	27010
Propylene Oxide	28	27010
Styrene	28	27010
Toluene Diisocyanate	28	27010
Vinyl Acetate	28	27010
Vinyl Chloride	28	28010
Other Products	28	27010
Storage & Handling	28	27010
Waste Disposal	28	27010
Fugitive	28	27010
PETROLEUM MARKETING & PRODUCTION		
Crude Oil Production	NA	08001
Natural Gas Liquids	NA	08003
Crude Oil Storage		
Oil Field Storage	NA	08001
Refinery Storage	29	31011
Crude Oil Loading		
Tank Car/Truck	NA	NA
Ship & Barge	NA	NA
Tanker Ballasting	NA	NA
Refinery Product Loading		
Gasoline Tank Car	NA	NA
Tanker & Barge	NA	NA
Gasoline Storage at Refineries	29	31011
Bulk Gasoline Terminals		
Transfer	NA	NA
Storage	NA	NA

Table A-4 (continued)

TRENDS EMISSION SOURCE CATEGORY	SIC	NEA
PETROLEUM MARKETING & PRODUCTION (*continued*)		
Gasoline Bulk Plants		
Transfer	NA	NA
Storage	NA	NA
Gasoline Service Stations		
Loading (Stage 1)	NA	NA
Unloading (Stage 2)	NA	NA
Other Products		
Jet Naphtha Storage	NA	NA
Jet Naphtha Transfer	NA	NA
Kerosene Storage	NA	NA
Distillate Oil Storage	NA	NA
SURFACE COATING OPERATIONS		
Large Appliances	36	54000
Magnet Wire	33	38990
Automobiles	37	59000
Cans	34	39000
Metal Coils	33	38990
Paper	26	24990
Fabric	22	16000
Metal Furniture	25	22000
Wood Furniture	25	22000
Flat Wood Products	24	20990
Plastic Parts	30	32000
Large Ships	37	61990
Aircraft	37	60000
Railroads	37	61990
Machinery	35	50000
Other Metal Products	34	42000
Miscellaneous Processes	34	42000
Maintenance Coatings	NA	12000
MISCELLANEOUS ORGANIC SOLVENT EVAPORATION		
Architectural Coating		
Auto Refinishing	NA	11002
Cutback Asphalt Paving	NA	NA
Pesticides	NA	12000
Other Solvent Use	NA	02000
	NA	NA

Note: NA = Not Applicable. TRENDS source classification code description exists, but for those codes with an "NA" in the SIC column and NEA column, emissions are not assigned to industries. Those source classification codes with an "NA" in only the SIC column are processes assigned to an industry in the nonmanufacturing portion of the industrial sector. Hence, these emissions are assigned to industries in spreadsheet NEA7085.WK3, and not assigned to industries in spreadsheet SIC7090.WK3.

Table A-5

Concordance Between the TRENDS Emission Source Categories, SIC Codes, and NEA Codes for Emissions of Carbon Monoxide

TRENDS EMISSION SOURCE CATEGORY	SIC	NEA
INDUSTRIAL PROCESSES		
Petroleum Refineries		
F.C.C.	29	31011
T.C.C.	29	31011
Process Heaters		
Oil	29	31011
Gas	29	31011
Asphalt Roofing	29	31990
Iron Foundries	33	37990
Steel Manufacturing		
Sintering	33	37990
B.O.F.	33	37990
Electric Arc	33	37990
By-Product Coke	33	37011
Blast Furnace	33	37012
Primary Aluminum	33	38040
Ammonia	28	29000
Carbon Black Production		
Oil Process	28	27040
Gas Process	28	27040
TiO2 Chloride Process	28	27040
Charcoal	28	27040
Petrochemicals		
Acetic Acid	28	27010
Acryonitrile	28	27010
Cyclonhexanol/none	28	27010
Dimethyl Terephthalate	28	27010
Ethylene Dichloride	28	27010
Formaldehyde	28	27010
Maleic Anhydride	28	27010
Phthalic Anhydride	28	27010
Kraft Pulp & Paper	26	24020
Lime	32	36990

Table A-6

Concordance Between the TRENDS Emission Source Categories, SIC Codes and NEA Codes for Emissions of Lead

TRENDS EMISSION SOURCE CATEGORY	SIC	NEA
IRON & STEEL INDUSTRY		
Coke	33	37011
Blast Furnace	33	37012
Sintering-Windbox	33	37990
Open Hearth	33	37990
B.O.F.	33	37990
Electric Arc Furnace	33	37990
PRIMARY NON-FERROUS METALS INDUSTRY		
Copper Production		
Roasting	33	38990
Smelting	33	38990
Converting	33	38990
Zinc Production		
Sintering	33	38990
Vertical Retort	33	38990
Horizontal Retort	33	38990
Lead Production		
Sintering	33	38990
Blast Furnace	33	38990
Reverberatory	33	38990
Ferro-alloy Production		
Ferrosilicon	33	37990
Silicon Metal	33	37990
Silico-Manganese	33	37990
Ferro-Mg-E1	33	37990
Ferro-Mg-B1	33	37990
Ferro-Mang (std)	33	37990
Ferrochrome-Silicon	33	37990
High Carbon Ferro	33	37990
SECONDARY METALS INDUSTRY		
Grey Iron Foundries		
Cupola	33	37990
Electric Induction	33	37990
Lead		
Pot Furnace	33	38990
Reverberatory Furnace	33	38990
Blast Furnace	33	38990

NOTE: see note at end of Table A-4 for explanation of "NA"

Table A-6 (continued)

TRENDS EMISSION SOURCE CATEGORY	SIC	NEA
SECONDARY METALS INDUSTRY (*continued*)		
Copper		
High-Pb (58%)	33	38990
Red-Yellow-Br (15%)	33	38990
Other Alloys (7%)	33	38990
Battery Production		
Grid Casting	36	58000
Paste Mixing	36	58000
Lead Oxide Mill	36	58000
Three Process Oper.	36	58000
Lead Reclaim. Furnace	36	58000
Lead Oxide/Pigment		
Barton Pot	28	30000
Red Lead	28	30000
White Lead	28	30000
MINERAL PRODUCTS INDUSTRY		
Ore Crushing/Grinding		
Lead Ore	NA	06002
Zn, Cu, Cu-Zn Ores	NA	06002
Pb-Zn, Cu-Pb, Cu-Pb-Zn Ores	NA	06002
Cement Manufacturing		
Wet Kiln/Cooler	32	36010
Wet Dryer/Grinder	32	36010
Dry Kiln/Cooler	32	36010
Dry Dryer/Grinder	32	36010
Glass Production		
Lead-Glass	32	35000
MISCELLANEOUS PROCESS SOURCES		
Lead Alkyl Production		
Electrolytic Process	28	27010
Sodium Lead Alloy		
Recovery Furnace	28	27010
TEL Process Vents	28	27010
TML Process Vents	28	27010
Sludge Pits	28	27010
Miscellaneous Products		
Type Metal Production	35	48000
Can Soldering	34	39000
Cable Covering	33	38990
Ammunition (Other)	34	13990

APPENDIX B

CONCORDANCE BETWEEN SIC CODES AND NEA CODES

Table B-1
Concordance Between SIC Codes and NEA Codes

SIC	Industry title	NEA
20	Food and kindred products	14000
21	Tobacco products	15000
22	Textile mill products	16000, 17000, 18990
23	Apparel and other textile products	18040 (incl. SIC 39996), 19000
24	Lumber and wood products	20070, 20990, 21000, 61060
25	Furniture and fixtures	22000, 23000
26	Paper and allied products	24020, 24990, 25000
27	Printing and publishing	26000
28	Chemicals and allied products	27010 (excl. SIC 28195), 27020, 27030, 27040, 28010, 28020, 28990, 29000, 30000
29	Petroleum and coal products	31011, 31012, 31990
30	Rubber and miscellaneous products	32000
31	Leather and leather products	33000, 34000
32	Stone, clay, and glass products	35000, 36010, 36990
33	Primary metal products	37011, 37012, 37990, 38040 (incl. SIC 21895), 38990
34	Fabricated metal products	13990, 37999, 39000, 40000, 41010, 41990, 42000
35	Industrial machinery and equipment	43000, 44000, 45000, 46000, 47000, 48000, 49000, 50000, 51000, 52000
36	Electric and electronic equipment	53990, 54000, 55000, 56000, 57000, 58000
37	Transportation equipment	13010, 13030, 59000, 60000, 61990
38	Instruments and related products	53010, 62000, 63000
39	Miscellaneous manufacturing products	64000 (excl. SIC 39996)

Source: Derived from Price and Wendling, 1986.

APPENDIX C

NEA SECTORING PLAN

NEA Code	Industry Title	SIC Code
	AGRICULTURE	
01000	Livestock and livestock products	02 (ex. 0254, pt. 0219, pt. 0259, pt. 0291), pt. 0191
02000	Other agricultural products	01 (ex. pt. 0191), pt. 0219, pt. 0259, pt. 0291
03000	Forestry and forestry products	08 (ex. 085), 09 (ex. 092)
04000	Agricultural, forestry and fishery services	0254, 07 (ex. 074), 085, 092
	MINING	
05000	Iron and feroalloy ores mining	101, 106
06001	Uranium - radium - vanadium ores mining	1094
06002	Nonferrous metal ores mining	102, 103, 104, 105, pt. 108, 109 (ex. 1094)
07010	Anthracite coal mining	pt. 11
07020	Bituminous and lignite coal mining	pt. 12
08001	Crude petroleum	pt. 131
08002	Natural gas	pt. 131
08003	Natural gas liquids	132
09000	Stone and clay mining and quarrying	141, 142, 144, 145, pt. 148, 149
10000	Chemical and fertilizer mineral mining	147
	CONSTRUCTION	
11001	Oil and gas well drilling	pt. 138
11002	New construction	pt. 15, pt. 16, pt. 17, pt. 108, pt. 11, pt. 12, pt.148
12000	Maintenance and repair construction	pt. 15, pt. 16, pt. 17, pt. 138

NEA Code	Industry Title	SIC Code
	MANUFACTURING	
13990	Ordnance and accessories	348
13010	Guided missiles and space vehicles	3761
13030	Tanks and tank components	3795
14000	Food and kindred products	20
15000	Tobacco manufactures	21
16000	Broad and narrow fabrics, yarn and threadmills	221, 222, 223, 224, 226, 228
17000	Miscellaneous textile goods & floor coverings	227, 229
18990	Knitting mills	225
18040	Apparel made from purchased materials	231, 232, 233, 234, 235, 236, 237, 238, 39996
19000	Miscellaneous fabricated textile products	239
20990	Lumber and wood products	241, 242, 243, 249, 2448
20070	Prefabricated wood buildings	2452
21000	Wood containers	244 (ex. 2448)
22000	Household furniture	251
23000	Other furniture and fixtures	252, 253, 254, 259
24020	Paper mills, except building paper	262
24990	Paper and applied products, ex. containers, boxes, paper mills	261, 263, 264, 266
25000	Paperboard containers and boxes	265
26000	Printing and publishing	27

NEA Code	Industry Title	SIC Code
	MANUFACTURING (continued)	
27010	Industrial chemicals	281 (ex. 28195), 2865, 2869
27020	Fertilizers	2873, 2874, 2875
27030	Pesticides & agricultural chemicals, n.e.c.	2879
27040	Miscellaneous chemical products	2861, 289
28010	Plastic materials and resins	2821
28020	Synthetic rubber	2822
28990	Cellulosic man made fibers & organic fibers	2823, 2824
29000	Drugs, cleaning and toilet preparations	283, 284
30000	Paints and allied products	285
31011	Petroleum refining	291
31012	Miscellaneous products of petroleum & coal	299
31990	Paving mixtures, blocks, asphalt felts and coatings	295
32000	Rubber and miscellaneous plastics products	30
33000	Leather tanning and finishing	311
34000	Footwear and other leather products	313, 314, 315, 316, 317, 319
35000	Glass and glass products	321, 322, 323
36010	Cement, hydraulic	324
36990	Stone and clay products, ex. cement hydraulic	325, 326, 327, 328, 329
37011	Coke oven products	pt. 3312
37012	Blast furnaces and basic steel ex. coke oven products	331 (ex. pt. 3312)

NEA Code	Industry Title	SIC Code
	MANUFACTURING (continued)	
37990	Primary iron and steel ex. blast furnaces and basic steel	332, 339
37999	Forgings	3462, 3463
38040	Primary aluminum	3334, 28195
38990	Primary nonferrous metals, ex. primary aluminum	333 (ex. 3334), 334, 335, 336
39000	Metal containers	341
40000	Heating, plumbing, and fabricated structural metal products	343, 344
41010	Screw machine products	345
41990	Metal stampings	346 (ex. 3462, 3463)
42000	Other fabricated metal products	342, 347, 349
43000	Engines and turbines	351
44000	Farm and garden machinery	352
45000	Construction and mining machinery	3531, 3532, 3533
46000	Materials handling machinery & equipment	3534, 3535, 3536, 3537
47000	Metalworking machinery and equipment	354
48000	Special industry machinery and equipment	355
49000	General industrial machinery and equipment	356
50000	Miscellaneous machinery ex. electrical	359
51000	Office, computing & accounting machines	357
52000	Service industry machines	358

NEA Code	Industry Title	SIC Code
	MANUFACTURING (continued)	
53990	Electrical transmission and distribution equipment	361, 362
53010	Instruments to measure electricity and industrial apparatus	3825
54000	Household appliances	363
55000	Electric lighting and wiring equipment	364
56000	Radio, television, and communication equipment	365, 366
57000	Electronic components and accessories	367
58000	Miscellaneous electrical machinery, equipment and supplies	369
59000	Motor vehicles and equipment	371
60000	Aircraft and parts	372, 376 (ex. 3761)
61990	Other transportation equipment	373, 374, 375, 379 (ex. 3795)
61060	Mobile homes	2451
62000	Professional, scientific and controlling instruments and supplies	381, 382 (ex. 3825), 384, 387
63000	Optical, ophthalmic, and photographic equipment and supplies	383, 385, 386
64000	Miscellaneous manufacturing	39 (ex. 39996)

Source: Price and Wendling (1986, Appendix B)

APPENDIX D

DIFFERENCES IN THE ASSIGNMENT OF PROCESS EMISSIONS BETWEEN THIS REPORT AND THE *1940-1990 NAPEE*

With the exception of Pb emissions, *National Air Pollutant Emission Estimates, 1940-1990* (U.S. EPA 1991a, pp. 76-81) assigns SIC codes to most industrial process source categories.[29] This section compares the assignment of SIC codes to industrial process categories by the *1940-1990 NAPEE* and this report.[30] For NO_x and CO emissions, the *1940-1990 NAPEE* and this report assign industrial process categories to the same two-digit SIC manufacturing industries. However, there are several cases when the *1940-1990 NAPEE* and this report assign PM, SO_x, and VOC emissions from industrial processes to different industries. This Appendix discusses the cases when this report and the *1940-1990 NAPEE* assign different SIC codes to industrial process categories.

D.1. PM EMISSIONS

For PM emissions, the *1940-1990 NAPEE* and this report assign industrial process source categories to the same two-digit SIC manufacturing industries. However, the *1940-1990 NAPEE* assigns PM emissions from the Grain Elevator category (the "Country Elevators" and "Terminal Elevators" source categories in this report) to SIC codes 4421 (this code should be SIC 4221) and 5153. However, this report assigns emissions from this category to NEA sector 02000 (SIC code 0723 - which includes the drying and cleaning of grain).

This report assigns emissions from the "Alfalfa Dehydrators" category (part of the "Grain Elevator" category in the *1940-1990 NAPEE*) to SIC code 20. This assignment is justified by SIC code 2048 including "alfalfa cubed" and "alfalfa, prepared as feed for animals" (Executive Office of the President, 1987, p. 76). However, the *1940-1990 NAPEE* assigns from emissions from the "Grain Elevator" category to SIC codes 4421 (this code should be SIC 4221) and 5153.

D.2. SO_x EMISSIONS

The *1940-1990 NAPEE* assigns SO_x emissions from the "Natural Gas Production" category (the "Sulfur Recovery Plants - Natural Gas Fields" category in this report) to SIC code 1311 (part of NEA code 08002). However, this report assigns these emissions to SIC code 28 (chemicals and allied products). In addition, the *1940-1990 NAPEE* assigns SO_x emissions from the "Petroleum Refining" category (the "Sulfur Recovery Plants - Refineries" category in this report) to SIC code 29 (petroleum refining and related products). However, this report assigns these emissions to SIC code 28 (chemicals and allied products). These assignments are adjusted because the *Standard Industrial Classification Manual, 1987* (Executive Office of the President 1987, p. 135) includes "sulfur, recovered or refined, including from sour natural gas" in SIC code 2819.

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[29] The level of emissions reported for source categories in the *1940-1990 NAPEE* and the spreadsheets for this report are virtually identical for 1986 to 1990. However, there are unexplained discrepancies in the emissions reported by the two sources for specific industrial process source categories for 1970 to 1985.

[30] Although the *1940-1990 NAPEE* assigns emissions to three and four digit SIC industries, this section focuses solely on discussing discrepancies for two-digit SIC industries.

The assignment of these emissions is further complicated by the *North American Industrial Classification System (NAICS) Manual* (Executive Office of the President 1998, pp. 69 and 1216). The NAICS assigns activities at sulfur recovery establishments to NAICS code 211112 (sulfur recovered from natural gas) and NAICS code 325188 (sulfur recovery or refining, except from sour gas). The *NAICS Manual* (pp. 773 and 807) states that NAICS 211112 corresponds to SIC 1321 and NAICS 325188 corresponds to part of SIC 2819.

Finally, there is a discrepancy in the SO_x emissions reported from the "Primary Copper" and "Primary Lead and Zinc" categories in the *1940-1990 NAPEE* and the "Copper (Roasting, Smelting, and Converting)," "Zinc Roasting," and "Lead Processing" source categories in the spreadsheets for this report. This report and the *1940-1990 NAPEE* both assign emissions from these categories to SIC 33 (metal products). However, it is not possible to reconcile the differences in emissions reported in the spreadsheets for this report and emissions reported in the *1940-1990 NAPEE*.

D.3. VOC EMISSIONS

This report assigns emissions of VOCs to eight two-digit SIC manufacturing industries (SIC codes 24-26, 32, 34-37) that are not assigned VOC emissions by the *1940-1990 NAPEE*. In addition, VOC emissions are assigned to NEA codes 02000, 08003, 11002, and 12000. The *1940-1990 NAPEE* assigns no VOC emissions to the SIC codes that correspond to these NEA codes.

First, there is a discussion of how to reconcile the sources of VOC emissions assigned to the nonmanufacturing sectors by this report with the *1940-1990 NAPEE*. There is then a reconciliation of the source categories of VOC emissions assigned to the manufacturing sector by this report with the *1940-1990 NAPEE*.

This report assigns VOC emissions from the "Miscellaneous Organic Solvent Evaporation - Pesticides" category to NEA sector 02000. This category is not classified as an industrial process emissions source category by the *1940-1990 NAPEE*.

This report assigns VOC emissions from the "Petroleum Marketing and Production - Crude Oil Production," and "Petroleum Marketing and Production - Crude Oil Storage, Oil Field Storage" categories to NEA sector 08001. These categories are part of the *1940-1990 NAPEE* category "Crude Oil Production, Storage and Transfer." The *1940-1990 NAPEE* assigns these categories to SIC industries 1311 (part of NEA sector 08001) and 4463.

This report assigns VOC emissions from the "Petroleum Marketing and Production - Natural Gas Liquids" category to NEA sector 08003. This category is part of the *1940-1990 NAPEE* category "Crude Oil Production, Storage and Transfer." The *1940-1990 NAPEE* assigns this category to SIC industries 1311 (part of NEA sector 08001) and 4463.

This report assigns VOC emissions to NEA sector 11002 from a category ("Miscellaneous Organic Solvent Evaporation - Architectural Coating") that is not classified as an industrial process

source category by the *1940-1990 NAPEE*. A subcategory of the *1940-1990 NAPEE* category "Surface Coating" (the subcategory entitled "Surface Coating Operations - Maintenance Coatings" in the NEA7085.WK3 and SIC7090.WK3 spreadsheets) is assigned to NEA sector 12000. The "Surface Coating" category is not assigned a SIC code by the *1940-1990 NAPEE*.

This report assigns VOC emissions from the "Miscellaneous Solvent Evaporation - Cutback Asphalt Paving" category to NEA sector 11002. This category is not treated as an industrial process source category by the *1940-1990 NAPEE*.

Most of the discrepancies between the amount of VOC emissions assigned to manufacturing industries in this report and the amount assigned to manufacturing industries in the *1940-1990 NAPEE* are attributable to the fact that this report assigns emissions from source categories that are not assigned SIC codes by the *1940-1990 NAPEE*. Assigning emissions from the "Surface Coating" category, which were not assigned a SIC code in the *1940-1990 NAPEE*, is the sole source of the discrepancies between the *1940-1990 NAPEE* and this report for the following two-digit SIC manufacturing industries (the relevant subcategories of the "Surface Coating Operations" category in the NEA7085.WK3 and SIC7090.WK3 spreadsheets are in parentheses after each SIC code): SIC 22 ("Fabric"), SIC 24 ("Flat Wood Products"), SIC 25 ("Metal Furniture" and "Wood Furniture"), SIC 26 ("Paper"), SIC 30 ("Plastic Parts"), SIC 33 ("Magnet Wire" and "Metal Coils"), SIC 34 ("Cans," "Other Metal Products," and "Miscellaneous Processes"), SIC 35 ("Machinery"), SIC 36 ("Large Appliances"), and SIC 37 ("Automobiles," "Large Ships," "Aircraft," and "Railroads"). Of these assignments, the most difficult decision involves the assignment of "Metal Coils."

This report assigns "Metal Coils" to SIC 33 because the *1987 Standard Industrial Classification Manual* lists coils within SIC codes 3353, 3354, and 3355. However, *Regional Interim Emission Inventories (1987 - 1991), Volume I: Development Methodologies* (U.S. EPA 1993, p. 62) associates coil coating with SIC 344.

The source category "Other Processes - Glass Manufacturing" is assigned to SIC 32. Probably due to the relatively small quantity of emissions associated with it, this source category is not listed as an industrial process emission in the *1940-1990 NAPEE*.

Neither the *1940-1990 NAPEE* nor this report assigns SIC codes to the following source categories: (1) "Adhesives," (2) "Degreasing," (3) "Solvent Extraction," and (4) "Other Processes - Organic Solvent" (see section 3.3.3.6.). The "Dry Cleaning" category was assigned to SIC code 721 by the *1940-1990 NAPEE*. Since dry cleaning is not part of the industrial sector, it was not assigned to an industry in this report.

This report assigns more VOC process emissions to SIC 28 than the *1940-1990 NAPEE* because it assigns emissions from the "Miscellaneous Industrial Processes - Plastics Manufacture" category to SIC 28. The *1940-1990 NAPEE* assigns these emissions to SIC codes 2821 and 3079 (Executive Office of the President 1972, p. 131 - 1972 SIC code, Misc. Plastics Products).

There are two explanations why more VOC process emissions are assigned to SIC 29 by this report relative to the emissions assigned to SIC 29 by the *1940-1990 NAPEE*. First, there is a difference in assigning emissions from the "Petroleum Marketing and Production - Crude Oil Storage, Refinery Storage" subcategory. This source is part of the "Crude Oil Production, Storage and Transfer" category in the *1940-1990 NAPEE*. The *1940-1990 NAPEE* assigns this source category to SIC industries 1311 and 4463. However, this report assigns these emissions to SIC 29 (see U.S. EPA 1998, p. 3-192). Second, there is a difference in assigning emissions from the "Petroleum Marketing and Production - Gasoline Storage at Refineries" subcategory. This source is part of the *1940-1990 NAPEE* category "Petroleum Product Storage and Transfer." The *1940-1990 NAPEE* assigns this category to SIC industries 5171 and 5541. This report assigns these emissions to SIC 29 (see U.S. EPA 1998, p. 3-192).

The "Crude Oil Loading" subcategory of the "Crude Oil Production, Storage, and Transfer" category, which is assigned to SIC codes 1311 and 4463 in the *1940-1990 NAPEE*, is not assigned an SIC code in this report. In this report, the remaining subcategories of the "Petroleum Product Storage and Transfer" category (i.e., "Refinery Product Loading," "Bulk Gasoline Terminals," "Gasoline Bulk Plants," "Gasoline Service Stations," and "Other Products"), which are assigned to SIC industries 5171 and 5541 in the *1940-1990 NAPEE*, are not assigned to industries within the industrial sector.

APPENDIX E

EMISSIONS OF TWO-DIGIT SIC MANUFACTURING INDUSTRIES

Table E-1
Emissions from SIC 20 (Food and Kindred Products)
(thousand metric tons)[1]

Year	PM	SO_x	NO_x	VOC	CO	Pb
1970	216.65	386.21	129.37	191.46	20.85	840.05
1971	177.45	306.95	115.89	190.79	19.55	787.59
1972	153.37	321.56	117.40	188.62	19.52	787.07
1973	136.80	313.25	118.10	184.13	19.69	812.46
1974	99.55	231.97	93.31	181.92	15.98	730.89
1975	101.26	235.65	94.82	173.09	15.90	839.37
1976	82.10	231.37	95.80	174.13	15.92	799.89
1977	80.28	240.26	95.32	173.96	15.77	827.06
1978	79.26	268.32	104.21	177.48	16.88	871.50
1979	84.41	243.70	96.81	179.34	15.77	321.27
1980	77.55	225.01	94.37	174.52	15.95	320.87
1981	81.02	215.36	95.32	180.12	16.38	234.47
1982	84.48	228.55	98.11	182.43	16.42	154.54
1983	51.59	188.49	87.70	179.61	15.07	47.60
1984	62.41	201.49	92.15	156.38	15.62	35.26
1985	66.04	203.33	94.90	171.79	16.08	33.87
1986	75.59	258.23	113.39	156.71	18.44	36.68
1987	61.43	253.48	114.05	162.22	18.35	33.90
1988	60.48	259.16	119.19	168.57	19.18	31.28
1989	62.73	267.83	125.02	156.67	20.26	31.56
1990	100.21	302.58	140.01	157.15	21.91	32.69

[1] except Pb, which is in metric tons.

Table E-2
Emissions from SIC 21 (Tobacco Products)
(thousand metric tons)[1]

Year	PM	SO_x	NO_x	VOC	CO	Pb
1970	5.82	16.49	4.28	0.03	0.57	38.72
1971	3.53	12.20	3.33	0.03	0.45	38.51
1972	2.41	11.60	3.12	0.03	0.41	40.07
1973	2.15	11.58	3.18	0.03	0.42	45.23
1974	1.91	11.86	3.29	0.03	0.44	51.66
1975	1.63	10.63	3.06	0.03	0.41	50.31
1976	1.37	11.25	3.29	0.03	0.42	50.01
1977	1.73	14.02	4.03	0.03	0.53	47.80
1978	2.02	15.70	4.55	0.03	0.59	36.16
1979	1.99	14.33	4.22	0.03	0.55	13.44
1980	2.35	14.44	4.30	0.03	0.57	11.23
1981	2.43	14.94	4.58	0.03	0.62	9.24
1982	2.11	15.73	4.83	0.03	0.64	6.08
1983	1.20	16.17	5.07	0.03	0.68	2.22
1984	1.15	16.34	5.24	0.03	0.70	1.70
1985	1.41	19.45	6.37	0.04	0.84	2.13
1986	1.14	19.82	6.51	0.04	0.85	1.97
1987	1.29	22.71	7.90	0.05	1.03	1.92
1988	1.39	25.86	9.22	0.05	1.21	1.06
1989	1.36	25.28	9.08	0.05	1.20	1.12
1990	1.62	27.31	10.27	0.06	1.35	1.26

[1] except Pb, which is in metric tons.

Table E-3
Emissions from SIC 22 (Textile Mill Products)
(thousand metric tons)[1]

Year	PM	SO_x	NO_x	VOC	CO	Pb
1970	47.66	158.68	45.00	161.13	6.44	548.47
1971	33.98	134.93	42.10	166.75	6.28	547.72
1972	23.10	125.38	39.12	188.94	5.87	523.64
1973	18.64	111.36	36.18	202.61	5.46	497.37
1974	13.90	90.77	29.95	190.84	4.57	420.40
1975	12.86	88.69	29.63	176.92	4.43	475.46
1976	11.85	101.42	33.81	196.18	4.88	487.34
1977	12.08	110.00	34.80	194.14	4.97	510.96
1978	10.91	100.97	33.11	193.31	4.73	497.72
1979	10.55	88.87	30.17	200.49	4.37	188.19
1980	10.37	78.24	27.16	189.12	4.13	170.95
1981	11.11	78.76	28.89	181.62	4.49	123.72
1982	9.13	76.05	27.12	165.31	4.07	69.68
1983	5.32	69.65	26.79	178.92	4.13	22.84
1984	5.33	73.34	27.96	184.05	4.29	16.54
1985	5.39	72.54	28.41	187.34	4.38	16.08
1986	5.16	83.11	31.62	189.75	4.74	17.76
1987	5.04	81.42	31.60	202.22	4.73	17.17
1988	4.60	76.99	30.93	178.13	4.68	16.76
1989	4.41	73.53	30.69	180.79	4.76	16.25
1990	4.68	73.57	31.74	184.29	4.86	14.92

[1] except Pb, which is in metric tons.

Table E-4
Emissions from SIC 23 (Apparel and Other Textile Products)
(thousand metric tons)[1]

Year	PM	SO_x	NO_x	VOC	CO	Pb
1970	6.99	19.94	7.24	0.10	1.24	35.33
1971	4.67	15.74	6.52	0.10	1.17	33.00
1972	2.86	13.45	5.81	0.09	1.07	28.92
1973	1.89	10.14	4.96	0.09	0.95	25.76
1974	1.06	6.80	3.86	0.07	0.77	21.07
1975	1.07	7.74	3.78	0.06	0.70	38.24
1976	0.92	8.42	4.01	0.07	0.73	38.87
1977	1.02	9.72	4.45	0.08	0.81	42.09
1978	0.94	8.90	4.50	0.08	0.84	38.34
1979	0.80	7.18	3.47	0.05	0.63	15.74
1980	0.92	7.07	3.54	0.05	0.66	14.58
1981	1.08	7.92	4.09	0.06	0.77	11.43
1982	0.82	6.95	3.33	0.05	0.60	6.32
1983	0.44	5.65	2.97	0.04	0.54	2.09
1984	0.39	5.20	2.81	0.04	0.52	1.38
1985	0.38	4.88	2.75	0.04	0.52	1.26
1986	0.30	4.67	2.47	0.03	0.45	0.94
1987	0.38	5.60	2.85	0.04	0.51	1.78
1988	0.42	6.53	3.54	0.05	0.64	1.75
1989	0.43	6.73	3.63	0.05	0.65	1.84
1990	0.37	5.39	3.01	0.04	0.54	1.96

[1] except Pb, which is in metric tons.

Table E-5
Emissions from SIC 24 (Lumber and Wood Products)
(thousand metric tons)[1]

Year	PM	SO_x	NO_x	VOC	CO	Pb
1970	84.93	40.60	19.15	58.74	3.68	145.23
1971	87.69	27.94	16.46	67.12	3.36	90.44
1972	90.97	31.95	16.92	73.62	3.37	106.17
1973	91.75	34.17	18.03	73.84	3.55	121.28
1974	80.86	29.22	15.21	71.68	2.96	108.99
1975	74.54	22.67	13.46	69.27	2.71	127.14
1976	85.86	28.21	14.47	78.27	2.74	157.19
1977	87.23	23.28	12.66	80.26	2.50	101.16
1978	88.22	24.63	13.56	82.77	2.65	124.89
1979	84.34	22.54	11.55	84.20	2.17	63.72
1980	73.75	19.10	10.03	74.69	1.95	57.82
1981	67.72	15.59	9.28	63.19	1.89	35.12
1982	59.92	11.95	6.91	51.14	1.38	16.12
1983	72.09	9.03	5.98	50.72	1.22	5.20
1984	83.61	10.08	6.05	50.73	1.23	3.98
1985	83.17	10.44	6.29	11.74	1.28	4.08
1986	93.17	13.33	7.34	13.76	1.46	4.86
1987	99.17	12.15	7.40	13.17	1.52	3.83
1988	98.42	9.19	6.47	18.95	1.37	2.63
1989	96.78	9.15	6.82	15.85	1.45	2.84
1990	104.35	7.99	6.30	5.93	1.34	2.11

[1] except Pb, which is in metric tons.

Table E-6
Emissions from SIC 25 (Furniture and Fixtures)
(thousand metric tons)[1]

Year	PM	SO_x	NO_x	VOC	CO	Pb
1970	10.49	26.80	7.70	224.37	1.13	38.56
1971	5.74	17.45	6.05	280.37	0.98	32.05
1972	4.18	17.84	6.42	315.08	1.07	37.32
1973	2.46	11.83	4.92	297.67	0.87	29.58
1974	1.65	9.27	4.29	273.06	0.79	27.80
1975	1.35	8.42	3.73	247.15	0.66	29.93
1976	0.88	7.16	3.47	261.85	0.63	26.01
1977	1.07	8.56	4.05	252.97	0.74	21.70
1978	1.00	8.21	4.09	266.67	0.76	20.62
1979	0.91	7.30	3.52	280.05	0.64	9.85
1980	0.89	6.51	3.24	256.95	0.60	11.42
1981	0.95	6.52	3.37	219.50	0.63	7.27
1982	0.71	5.74	3.00	195.96	0.55	4.15
1983	0.33	4.07	2.51	216.40	0.48	1.12
1984	0.34	4.43	2.71	229.24	0.52	0.86
1985	0.33	4.19	2.82	397.83	0.55	0.80
1986	0.31	4.67	2.80	361.87	0.53	0.94
1987	0.39	6.07	3.47	446.27	0.64	0.92
1988	0.37	5.79	3.57	504.13	0.67	0.90
1989	0.46	7.52	4.20	494.81	0.76	0.98
1990	0.53	8.25	4.31	570.50	0.73	1.09

[1] except Pb, which is in metric tons.

Table E-7
Emissions from SIC 26 (Paper and Allied Products)
(thousand metric tons)[1]

Year	PM	SO_x	NO_x	VOC	CO	Pb
1970	858.52	965.78	235.95	596.33	578.28	2970.20
1971	734.25	888.15	229.17	587.21	579.46	3161.81
1972	660.15	904.51	227.06	666.02	621.01	3168.56
1973	488.59	869.64	221.03	666.79	642.71	3056.39
1974	440.38	891.60	229.02	593.58	643.48	3076.43
1975	312.60	773.52	201.79	498.99	571.63	3255.12
1976	258.77	837.70	219.14	525.62	651.52	3166.13
1977	254.88	854.82	213.07	531.27	657.44	3061.70
1978	198.90	816.35	206.63	608.53	677.08	3017.38
1979	200.83	794.21	205.35	610.71	685.68	1353.27
1980	211.07	794.44	196.61	569.40	747.67	1449.77
1981	171.81	760.41	199.49	437.51	744.29	973.60
1982	176.09	797.57	210.29	397.58	730.59	578.27
1983	144.62	760.82	207.38	457.88	783.89	181.80
1984	161.97	839.39	230.28	574.17	824.58	135.82
1985	165.63	893.79	250.78	420.32	823.39	136.90
1986	138.40	936.90	261.71	493.39	879.66	153.98
1987	139.36	915.54	256.20	510.97	904.78	154.83
1988	146.09	876.65	250.28	479.31	904.37	156.19
1989	123.61	888.60	255.49	479.39	940.41	162.53
1990	131.86	952.71	287.00	482.13	968.81	174.19

[1] except Pb, which is in metric tons.

Table E-8
Emissions from SIC 27 (Printing and Publishing)
(thousand metric tons)[1]

Year	PM	SO_x	NO_x	VOC	CO	Pb
1970	1.44	9.61	5.35	290.89	1.06	59.15
1971	0.89	6.51	4.79	273.09	1.00	42.32
1972	1.04	7.26	4.79	312.09	0.99	36.10
1973	1.26	7.78	4.95	318.69	1.01	31.57
1974	1.10	6.57	3.94	295.07	0.79	22.23
1975	1.00	6.91	4.14	254.57	0.82	32.35
1976	0.68	5.54	3.47	280.66	0.69	18.78
1977	0.68	5.99	4.02	292.08	0.83	21.03
1978	0.63	5.77	3.95	346.37	0.81	23.33
1979	0.63	5.73	3.91	353.07	0.79	12.77
1980	0.52	4.72	3.83	338.87	0.81	14.39
1981	0.42	3.87	3.96	257.48	0.88	10.43
1982	0.46	4.53	4.05	237.77	0.87	7.23
1983	0.29	3.11	3.65	274.07	0.81	2.01
1984	0.30	3.37	3.99	360.07	0.89	1.18
1985	0.26	2.75	3.88	327.87	0.88	0.64
1986	0.25	3.08	3.36	216.46	0.73	0.92
1987	0.17	1.53	3.02	191.16	0.72	0.88
1988	0.16	1.24	3.46	235.17	0.84	0.86
1989	0.09	0.34	3.49	235.17	0.87	0.00
1990	0.08	0.30	3.16	199.95	0.79	0.00

[1] except Pb, which is in metric tons.

Table E-9
Emissions from SIC 28 (Chemicals and Allied Products)
(thousand metric tons)[1]

Year	PM	SO_x	NO_x	VOC	CO	Pb
1970	581.81	1787.20	556.64	1365.78	2263.87	2647.81
1971	483.44	1673.62	537.25	1367.88	2573.28	2656.83
1972	388.73	1714.54	529.38	1527.06	2220.70	3122.80
1973	342.39	1727.60	537.26	1674.23	2409.52	3439.38
1974	303.21	1593.37	538.19	1721.11	2355.90	3073.24
1975	245.80	1368.13	483.30	1514.74	2047.05	2498.00
1976	216.55	1232.27	479.83	1731.31	2184.18	3096.54
1977	224.57	1264.31	487.21	1840.34	2443.55	3108.81
1978	229.44	1261.09	469.67	1932.99	2353.47	3047.47
1979	227.50	1260.21	480.47	1988.15	2351.05	2092.60
1980	223.18	1140.86	440.51	1837.22	1993.75	1382.34
1981	218.38	1155.40	458.26	1753.58	2049.25	1040.90
1982	176.00	1073.73	391.58	1510.16	1585.90	812.98
1983	155.51	1078.83	367.17	1739.10	1712.00	625.00
1984	175.89	1094.25	399.22	1937.08	1930.63	551.21
1985	158.74	1082.09	388.67	1805.31	1825.81	393.93
1986	124.34	1140.53	374.59	1763.10	1756.02	304.48
1987	127.86	1143.68	384.94	1760.68	1763.59	322.74
1988	127.86	1143.54	391.36	1943.74	1873.08	319.81
1989	131.43	1133.41	400.57	1919.01	1878.53	312.09
1990	136.69	1179.12	409.18	1881.67	1783.39	193.62

[1] except Pb, which is in metric tons.

Table E-10
Emissions from SIC 29 (Petroleum and Coal Products)
(thousand metric tons)[1]

Year	PM	SO_x	NO_x	VOC	CO	Pb
1970	639.87	618.97	231.44	894.81	2016.48	81.43
1971	629.92	627.42	234.57	949.05	2080.50	69.49
1972	626.06	643.10	239.12	982.05	2116.85	71.98
1973	663.03	676.73	250.74	1019.89	2151.16	73.29
1974	572.10	680.53	250.75	1049.68	2075.89	62.10
1975	387.77	659.89	244.31	1079.42	2056.19	70.26
1976	280.74	680.31	252.02	1102.20	1976.26	68.81
1977	191.02	727.50	269.33	1161.26	1889.81	77.03
1978	182.18	741.31	268.86	1188.13	1798.71	77.94
1979	187.35	708.53	257.24	1174.63	1714.12	38.51
1980	165.51	669.34	245.04	1156.94	1616.37	36.49
1981	138.11	605.16	216.36	1139.78	1125.79	24.47
1982	123.30	586.47	208.70	1069.43	715.50	17.08
1983	142.95	575.93	205.16	968.98	485.07	6.54
1984	172.83	594.45	208.63	944.88	395.07	4.99
1985	140.44	595.06	206.35	878.24	388.89	5.91
1986	145.80	667.07	228.18	847.23	373.48	9.71
1987	151.80	646.59	219.92	861.58	358.25	8.61
1988	145.27	648.94	225.54	872.63	337.77	3.75
1989	143.55	663.81	228.57	888.08	343.14	2.73
1990	151.87	683.82	233.55	879.84	426.04	1.89

[1] except Pb, which is in metric tons.

Table E-11
Emissions from SIC 30 (Rubber and Miscellaneous Plastic Products)
(thousand metric tons)[1]

Year	PM	SO_x	NO_x	VOC	CO	Pb
1970	37.53	102.22	29.97	63.09	4.45	199.37
1971	25.65	82.41	27.17	71.39	4.27	192.76
1972	23.86	105.26	33.33	77.66	5.10	269.95
1973	21.58	104.22	33.23	75.91	5.00	299.67
1974	16.49	90.97	29.18	73.18	4.38	291.78
1975	11.73	73.47	24.83	63.41	3.75	301.35
1976	8.95	73.72	25.04	66.24	3.65	330.07
1977	9.29	81.37	27.16	79.84	4.03	345.46
1978	7.51	67.31	23.80	79.41	3.59	304.38
1979	6.88	57.71	21.03	76.32	3.21	119.72
1980	6.36	47.58	18.00	62.98	2.89	101.01
1981	5.80	40.41	17.52	69.97	2.99	60.16
1982	4.24	36.02	15.73	67.08	2.66	37.42
1983	2.02	25.45	13.28	71.80	2.38	11.81
1984	1.84	23.86	12.86	81.24	2.36	8.94
1985	1.60	20.13	12.09	78.88	2.31	8.67
1986	1.72	24.10	13.19	78.13	2.42	9.94
1987	1.81	25.44	13.66	83.78	2.52	9.83
1988	1.52	21.84	13.19	82.65	2.50	9.06
1989	1.55	22.22	13.76	74.64	2.63	9.29
1990	1.63	23.00	13.41	79.07	2.47	9.45

[1] except Pb, which is in metric tons.

Table E-12
Emissions from SIC 31 (Leather and Leather Products)
(thousand metric tons)[1]

Year	PM	SO_x	NO_x	VOC	CO	Pb
1970	5.17	18.71	5.38	0.06	0.79	70.41
1971	3.02	12.78	4.06	0.05	0.62	53.46
1972	2.14	11.63	3.62	0.04	0.55	45.22
1973	1.56	9.18	2.94	0.04	0.45	37.64
1974	0.97	7.17	2.31	0.03	0.35	37.80
1975	0.84	6.52	2.28	0.03	0.36	41.28
1976	0.61	5.75	2.23	0.03	0.37	29.05
1977	0.68	6.93	2.28	0.03	0.34	39.39
1978	0.62	6.18	2.15	0.03	0.32	34.87
1979	0.54	5.22	1.84	0.02	0.27	14.91
1980	0.55	5.26	1.74	0.02	0.26	17.60
1981	0.49	4.59	1.62	0.02	0.25	13.38
1982	0.45	4.78	1.65	0.02	0.25	8.63
1983	0.27	3.45	1.40	0.02	0.22	3.07
1984	0.25	3.33	1.21	0.02	0.19	2.14
1985	0.25	3.35	1.21	0.02	0.19	2.27
1986	0.36	5.14	1.65	0.02	0.23	2.73
1987	0.36	5.13	1.63	0.02	0.24	2.65
1988	0.30	4.33	1.48	0.02	0.22	2.58
1989	0.30	4.27	1.52	0.02	0.24	2.80
1990	0.22	3.11	1.23	0.02	0.20	2.07

[1] except Pb, which is in metric tons.

Table E-13
Emissions from SIC 32 (Stone, Clay and Glass Products)
(thousand metric tons)[1]

Year	PM	SO_x	NO_x	VOC	CO	Pb
1970	2358.09	675.73	189.31	2.08	22.03	837.97
1971	2225.03	660.33	195.83	2.16	22.42	828.25
1972	1998.71	682.25	204.70	2.25	23.28	773.38
1973	1583.95	685.18	212.21	2.36	24.06	631.44
1974	1286.07	651.11	201.09	2.24	23.35	529.98
1975	1028.59	559.43	178.80	2.19	20.60	547.33
1976	905.72	620.77	195.50	2.45	22.30	530.85
1977	845.32	702.77	206.12	2.56	22.33	566.33
1978	850.19	743.61	216.52	2.68	22.71	576.25
1979	725.90	723.42	206.83	2.40	21.64	217.26
1980	569.41	654.34	188.76	2.27	19.70	177.52
1981	450.69	626.28	183.32	2.28	19.43	108.22
1982	354.45	548.22	160.03	2.07	14.71	68.22
1983	374.37	580.01	169.31	2.08	15.36	50.35
1984	423.19	628.15	178.46	2.06	16.24	50.36
1985	408.44	627.99	177.32	2.02	16.24	45.69
1986	346.14	614.90	176.26	2.07	16.12	31.81
1987	331.73	611.88	172.36	1.95	16.19	34.62
1988	349.01	644.34	184.64	2.12	17.66	31.58
1989	348.82	653.06	186.97	2.12	18.08	31.79
1990	359.21	656.46	184.72	2.01	17.50	31.49

[1] except Pb, which is in metric tons.

Table E-14
Emissions from SIC 33 (Primary Metal Industries)
(thousand metric tons)[1]

Year	PM	SO_x	NO_x	VOC	CO	Pb
1970	2093.09	5494.34	235.29	383.67	3331.49	21357.69
1971	1782.53	4778.22	209.60	281.24	3244.27	20154.62
1972	1717.37	4994.27	210.11	353.88	3375.45	15984.65
1973	1548.90	5080.11	213.36	372.01	3333.06	12986.28
1974	1321.56	4447.05	192.78	356.09	3129.57	11286.01
1975	1013.29	3693.98	171.39	328.52	2281.55	8689.68
1976	862.91	3618.85	168.83	338.48	2417.69	6123.91
1977	744.24	3274.01	162.92	314.74	2317.08	3934.23
1978	733.64	2840.25	164.34	294.29	2385.00	3833.17
1979	659.49	3061.42	160.87	314.00	2376.90	3412.92
1980	535.48	2329.16	136.02	271.64	2050.73	2506.44
1981	529.39	2592.45	144.20	251.62	2026.33	2135.87
1982	377.83	1952.30	101.37	172.69	1388.46	1905.89
1983	346.93	1855.70	106.21	165.39	1425.54	1648.52
1984	358.10	1878.36	110.49	187.13	1583.66	1543.54
1985	332.41	1577.22	105.99	176.21	1424.37	1715.25
1986	280.34	1458.53	96.35	158.82	1273.62	1498.20
1987	288.49	1510.55	97.54	174.26	1385.03	1480.81
1988	312.49	1580.65	103.48	197.31	1573.00	1570.59
1989	324.02	1560.93	101.95	200.03	1512.72	1724.90
1990	324.63	1598.96	105.04	201.38	1570.57	1629.93

[1] except Pb, which is in metric tons.

Table E-15
Emissions from SIC 34 (Fabricated Metal Products)
(thousand metric tons)[1]

Year	PM	SO_x	NO_x	VOC	CO	Pb
1970	27.83	94.52	39.15	974.79	6.99	422.57
1971	17.87	70.42	34.35	720.11	6.44	374.67
1972	12.98	67.64	33.94	869.52	6.45	355.52
1973	10.49	59.11	32.60	892.06	6.33	334.35
1974	6.87	43.34	25.89	779.76	5.13	274.49
1975	5.50	37.74	23.31	463.73	4.61	284.69
1976	4.40	37.27	23.71	557.37	4.69	272.86
1977	4.59	40.03	24.41	643.19	4.83	253.94
1978	4.11	36.14	24.16	885.01	4.87	229.04
1979	4.08	33.81	22.24	873.16	4.44	129.72
1980	3.66	27.62	21.05	838.26	4.37	116.38
1981	3.61	25.89	21.77	599.28	4.60	91.88
1982	3.44	28.03	21.13	465.04	4.33	68.65
1983	1.84	21.47	18.58	560.21	3.89	47.53
1984	1.72	20.77	18.43	873.40	3.89	49.14
1985	1.63	19.03	18.41	813.32	3.93	32.51
1986	1.48	20.00	18.04	761.18	3.80	32.90
1987	1.41	18.93	17.39	740.22	3.66	32.09
1988	1.39	18.90	19.03	257.28	4.05	31.91
1989	1.29	17.15	19.08	273.74	4.12	31.34
1990	1.32	17.05	17.45	235.39	3.69	4.23

[1] except Pb, which is in metric tons.

Table E-16
Emissions from SIC 35 (Industrial Machinery and Equipment)
(thousand metric tons)[1]

Year	PM	SO_x	NO_x	VOC	CO	Pb
1970	36.08	105.56	36.93	36.23	6.09	810.31
1971	25.22	84.14	33.31	40.42	5.75	661.06
1972	19.16	84.75	33.49	43.73	5.79	606.00
1973	16.21	77.19	32.71	46.13	5.76	602.86
1974	10.88	59.31	26.77	46.66	4.82	520.09
1975	9.30	55.74	24.94	46.63	4.40	434.82
1976	6.02	47.06	22.69	54.91	4.05	378.23
1977	6.19	49.72	23.24	56.91	4.17	305.98
1978	6.57	52.92	24.67	60.14	4.38	277.43
1979	7.02	52.53	24.19	62.29	4.26	162.19
1980	6.71	44.62	22.33	56.94	4.08	134.94
1981	6.24	41.74	22.26	49.07	4.15	101.73
1982	5.12	41.19	21.23	56.40	3.87	46.18
1983	2.52	31.68	17.52	48.68	3.24	17.60
1984	2.50	33.04	17.90	46.69	3.28	20.60
1985	2.41	31.07	17.49	43.68	3.24	9.27
1986	2.14	33.54	17.57	47.40	3.13	6.13
1987	2.03	32.01	17.85	44.04	3.21	5.07
1988	1.94	31.51	19.04	49.34	3.50	4.11
1989	1.83	29.29	18.70	45.88	3.51	4.38
1990	1.87	28.29	17.75	46.22	3.24	3.31

[1] except Pb, which is in metric tons.

Table E-17
Emissions from SIC 36 (Electric and Electronic Equipment)
(thousand metric tons)[1]

Year	PM	SO_x	NO_x	VOC	CO	Pb
1970	24.45	74.14	25.60	44.70	4.19	238.75
1971	14.63	54.31	21.96	54.29	3.82	230.99
1972	12.44	58.04	22.76	59.29	3.92	218.56
1973	11.79	56.82	22.86	54.59	3.93	207.97
1974	8.13	43.25	18.03	45.86	3.14	176.25
1975	5.61	34.48	15.29	39.03	2.69	174.91
1976	4.59	35.38	16.09	39.06	2.80	174.92
1977	4.57	36.70	16.50	36.17	2.92	170.49
1978	4.32	36.02	16.64	36.67	2.95	178.54
1979	4.64	35.82	16.01	36.70	2.77	108.21
1980	3.75	27.05	13.93	32.73	2.58	96.53
1981	3.84	26.89	14.39	26.60	2.69	94.40
1982	3.31	27.71	14.29	23.39	2.61	76.66
1983	1.80	22.49	12.93	25.69	2.42	64.76
1984	1.72	22.40	12.77	27.27	2.39	66.82
1985	1.78	22.56	13.32	15.03	2.51	65.46
1986	1.37	20.23	11.51	14.85	2.13	65.08
1987	1.15	16.74	10.04	13.89	1.89	71.00
1988	1.15	17.24	11.53	15.26	2.23	70.91
1989	1.19	18.05	11.48	14.46	2.18	72.26
1990	1.29	19.09	11.59	11.03	2.11	74.25

[1] except Pb, which is in metric tons.

Table E-18
Emissions from SIC 37 (Transportation Equipment)
(thousand metric tons)[1]

Year	PM	SO_x	NO_x	VOC	CO	Pb
1970	64.74	169.77	50.43	174.77	7.54	288.28
1971	47.65	143.05	46.30	194.77	7.18	263.74
1972	36.45	147.81	47.35	208.57	7.29	281.65
1973	30.20	133.56	44.44	214.05	6.88	288.70
1974	22.88	113.98	38.97	213.00	6.10	257.48
1975	18.74	103.48	36.56	210.47	5.68	248.96
1976	14.47	101.14	37.96	235.38	5.92	236.54
1977	13.26	98.75	36.09	241.47	5.64	235.65
1978	13.13	101.58	37.27	232.46	5.82	241.32
1979	13.67	99.93	36.44	218.55	5.63	108.33
1980	12.71	84.23	31.28	177.81	4.93	113.48
1981	13.10	84.77	32.59	131.60	5.20	83.00
1982	10.30	80.75	30.48	113.00	4.75	51.68
1983	5.60	73.36	29.54	133.15	4.71	17.11
1984	5.66	78.04	31.34	152.38	4.94	12.35
1985	5.90	79.33	32.77	169.74	5.19	12.74
1986	5.43	87.33	35.89	168.06	5.65	16.91
1987	4.96	79.31	33.54	179.10	5.31	16.29
1988	4.44	72.89	32.37	176.99	5.23	16.72
1989	4.49	73.81	33.67	170.63	5.50	16.25
1990	5.02	78.29	35.60	183.70	5.64	15.98

[1] except Pb, which is in metric tons.

Table E-19
Emissions from SIC 38 (Instruments and Related Products)
(thousand metric tons)[1]

Year	PM	SO_x	NO_x	VOC	CO	Pb
1970	15.79	43.07	11.74	0.10	1.64	87.54
1971	13.70	42.83	12.16	0.10	1.71	97.20
1972	11.25	47.08	13.16	0.11	1.83	106.02
1973	8.48	39.01	11.21	0.09	1.55	100.41
1974	7.14	37.93	10.87	0.09	1.49	111.91
1975	5.42	31.74	9.60	0.08	1.32	107.24
1976	4.04	29.31	9.64	0.09	1.37	83.17
1977	2.20	19.66	6.71	0.08	1.01	89.40
1978	2.62	22.12	7.47	0.08	1.10	80.83
1979	5.19	36.57	11.62	0.09	1.63	28.47
1980	5.24	32.59	10.64	0.09	1.53	28.38
1981	4.93	30.89	10.46	0.09	1.53	23.29
1982	4.45	33.74	11.36	0.09	1.63	15.70
1983	2.42	32.21	11.19	0.09	1.62	5.24
1984	2.43	34.03	12.07	0.10	1.74	4.10
1985	2.41	32.83	12.06	0.10	1.76	4.04
1986	2.27	38.36	13.52	0.10	1.89	5.18
1987	2.21	37.40	14.23	0.11	2.05	4.88
1988	2.10	37.13	14.28	0.11	2.04	4.55
1989	2.21	38.96	15.31	0.12	2.23	4.92
1990	2.65	43.37	17.37	0.13	2.46	4.46

[1] except Pb, which is in metric tons.

Table E-20
Emissions from SIC 39 (Miscellaneous Manufacturing Products)
(thousand metric tons)[1]

Year	PM	SO_x	NO_x	VOC	CO	Pb
1970	3.39	15.61	5.23	0.07	0.84	77.04
1971	2.49	13.63	5.10	0.07	0.85	76.91
1972	2.19	14.74	5.48	0.08	0.92	76.53
1973	1.71	12.15	4.77	0.07	0.81	63.76
1974	1.14	9.10	3.78	0.06	0.66	52.54
1975	0.73	6.79	3.03	0.05	0.53	55.45
1976	0.81	8.24	3.39	0.05	0.56	53.22
1977	0.71	7.22	3.17	0.05	0.56	38.71
1978	0.67	6.78	3.18	0.05	0.57	39.16
1979	0.62	5.96	2.87	0.04	0.52	14.87
1980	0.66	5.58	2.79	0.04	0.52	14.40
1981	0.70	5.42	2.84	0.04	0.53	10.30
1982	0.54	4.89	2.43	0.03	0.44	5.89
1983	0.35	4.47	2.35	0.03	0.43	2.25
1984	0.32	4.20	2.23	0.03	0.41	1.72
1985	0.32	4.13	2.18	0.03	0.40	1.85
1986	0.29	4.02	2.18	0.03	0.40	1.83
1987	0.37	5.42	2.64	0.03	0.46	1.78
1988	0.27	4.16	2.72	0.04	0.52	0.88
1989	0.28	4.29	2.76	0.04	0.53	0.96
1990	0.21	2.92	2.04	0.03	0.40	1.05

[1] except Pb, which is in metric tons.

APPENDIX F

ORGANIZATION OF SPREADSHEETS

Table F-1
Contents of spreadsheet NEA7085.WK3

NEA7085.WK3	**Description of contents of Sheet**
Sheet A	Original TRENDS data
Sheet B	Process emissions, by NEA code
Sheet C	Emissions from coal combustion, by NEA code
Sheet D	Emissions from natural gas combustion, by NEA code
Sheet E	Emissions from residual fuel oil combustion, by NEA code
Sheet F	Emissions from distillate fuel oil combustion, by NEA code
Sheet G	Emissions from all sources, by NEA code (total of sheets B through F)
Sheet H	Emissions from all sources for the twenty two-digit SIC manufacturing industries

Table F-2
Contents of spreadsheet SIC7090.WK3

SIC7090.WK3	**Description of contents of Sheet**
Sheet A	Outline of spreadsheet
Sheet B	Economic Activity, from TRENDS methodology
Sheet C	Emissions Factors, from TRENDS methodology
Sheet D	Control Efficiencies, from TRENDS methodology
Sheet E	Emissions calculation sheet for TRENDS methodology, by TRENDS source code
Sheet F	Emissions of Electric utilities sector, from TRENDS
Sheet G	Process emissions, by SIC code
Sheet H	Emissions from coal combustion, by SIC code
Sheet I	Emissions from natural gas combustion, by SIC code
Sheet J	Emissions from residual fuel oil combustion, by SIC code
Sheet K	Emissions from distillate fuel oil combustion, by SIC code
Sheet L	Emissions from all sources, by SIC code (total of sheets G through K)
Sheet M	Emissions by 2-digit SIC code (1970-1990)
Sheet N	Emissions by 2-digit SIC code from NEA7085.WK3 (1970-1985)
Sheet O	Comparison of estimates of emissions by 2-digit SIC code for NEA7085.WK3 and SIC7090.WK3 (1970-1985)

Table F-2 (continued)

SIC7090.WK3	**Description of contents of Sheet**
Sheet P	Output indexes : 1970-1990 (agriculture, 4 mining industries, construction, and 20 manufacturing industries)
Sheet Q	Federal Reserve Board, value added, 1992, 1987, 1982
Sheet R	Federal Reserve Board, production indexes, 1919-1985
Sheet S	Federal Reserve Board, production indexes, 1986-1999
Sheet T	BEA, gross output (1947-1987) : agriculture and construction
Sheet U	BEA, gross output (1987-1997) : agriculture and construction
Sheet V	Coal consumption (1982-1997) : agriculture, 4 mining industries, and construction)
Sheet W	Natural Gas consumption (1982-1997) : agriculture, 4 mining industries, and construction)
Sheet X	Distillate Fuel Oil consumption (1982-1997) : agriculture, 4 mining industries, and construction)
Sheet Y	Residual Fuel Oil consumption (1982-1997) : agriculture, 4 mining industries, and construction)
Sheet Z	Share of coal consumption of agriculture, 4 mining industries, and construction (1982-1997)
Sheet AA	Share of residual fuel oil consumption of agriculture, 4 mining industries, and construction (1982-1997)
Sheet AB	Share of distillate fuel oil consumption of agriculture, 4 mining industries, and construction (1982-1997)
Sheet AC	Share of natural gas consumption of agriculture, 4 mining industries, and construction (1982-1997)

APPENDIX G

PREPARATION OF REPORT AND PEER REVIEW PROCESS

G.1. PREPARING THE REPORT

This report was a product of research conducted by the EPA's National Center for Environmental Economics (NCEE) and the Environmental Law Institute (ELI). The methodology for disaggregating industrial emissions using energy use data was developed by NCEE. ELI's James Lockhart was responsible for applying the methodology to and developing spreadsheets from the EPA's national emission estimates. Gerhard Gschwandtner of E.H. Pechan and Associates provided useful insights concerning the TRENDS data.

Special thanks go to Sharon Nizich (Office of Air and Radiation, U.S. EPA) and Tom McMullen (Office of Air and Radiation, U.S. EPA) for providing information on the procedures employed to estimate emissions of air pollutants.

ELI's Anne S. Forrest, James Lockhart, and Charles Jung developed the draft report.

The EPA's Carl A. Pasurka, Jr. was responsible for editing the draft report and developing the final document.

G.2. DESCRIPTION OF THE REVIEW PROCESS

A draft of what emerged as *Statistical Methodology for Assigning Emissions to Industries in the United States: 1970 to 1990* was subjected to both inter- and intra-agency review. Representatives from the U.S. Bureau of Economic Analysis (U.S. Department of Commerce) and the Statistical Office of the European Communities were contacted for comment. Within EPA, representatives from the Office of Air and Radiation and the Office of Policy provided comments.

The following individuals provided helpful comments on the draft report (in alphabetical order):

Wiley Barbour (U.S. EPA, Office of Air and Radiation)
Ann Lawson (U.S. Department of Commerce, Bureau of Economic Analysis, Industry Economics Division)
Tom McMullen (U.S. EPA, Office of Air and Radiation)
Sharon Nizich (U.S. EPA, Office of Air and Radiation)
Anton Steurer (Statistical Office of the European Communities)

In addition to making numerous suggestions for changes in style, the reviews also made the following suggestions regarding the content of the report. Upon receipt of the comments, Carl Pasurka attempted to address and incorporate all comments to the maximum extent possible. The comments listed in this section do not always represent the exact wording of the original comments and may reflect a combination of more than one comment.

G.3. SPECIFIC COMMENTS AND RESPONSES

Comment: The report should highlight the fact that emissions from motor vehicles are not assigned to various industries.

Response: Section 1.1. now mentions that emissions from motor vehicles are not assigned to industries.

Comment: The use of fuel consumption data to assign emissions from fuel combustion ignores differences in control efficiencies, age of boilers, and variation in standards across industries.

Response: The importance of this assumption is highlighted in Section 3.2.1.1. of the report.

Comment: There should be some explanation of why certain source categories are not assigned to industries.

Response: Portions of section 1.1, 3.1,and 3.3 contain explanations of which source categories are excluded and some explanation as to why they are excluded.

Comment: It should be made clear that the estimates of emissions used in this report are generated by a methodology that was primarily a “top-down”approach.

Response: Sections 2.1 and 2.2 have been revised to clarify this point.

Comment: The estimates of emissions used in this report were generated by a methodology that EPA replaced several years ago.

Response: *Statistical Methodology for Assigning Emissions to Industries in the United States, Revised Estimates: 1970 to 1997,* which uses the revised EPA estimates of emissions, addresses this concern. In addition, the Summary (p. i), Section 1.1, Section 2.4, and Section 4 of this report mention that the emission estimates used in this report have been supplanted by revised estimates.

Comment: Is it possible to compare the results of this report with the estimates of emissions for industries that the Aerometric Information Retrieval System (AIRS) assembled for 1990?

Response: The methodology that generates the estimates of emissions used in *Statistical Methodology for Assigning Emissions to Industries in the United States, Revised Estimates: 1970 to 1997* makes use of some of the estimates from AIRS. The new methodology employed to estimate missions is described in Section 4 of *National Air Pollutant Emission Trends Procedures Document, 1900-1996 Projections 1999-2010* (U.S. EPA 1998).

Comment: The report should provide a list of Acronyms and Abbreviations.

Response: The report now includes a list of relevant Acronyms and Abbreviations.

Comment: The report should define "industrial sector."

Response: A definition of "industrial sector" is provided in footnote 5.

Comment: The report should define "fugitive emissions."

Response: This report provides a definition of "fugitive emissions" in footnote 14.

Comment: There should be a discussion of the potential uses of the data developed in the report.

Response: Within the Introduction section, the "Purpose of the Project" now contains an overview of some of the proposed uses of these data.

Comment: There should be a discussion of previous efforts by the EPA to assign emissions to SIC codes.

Response: Footnote 11 and Appendix D discuss the relationship between the estimates in this study and the assignment of process emissions to SIC codes by the *1940-1990 NAPEE*.

Comment: The discussion of the values in Table 4 should be clarified.

Response: The discussion of Table 4 in Section 3.1 has been revised.

Comment: There is a potential source of ambiguity between the terms source classification code (SCC) and source classification code.

Response: Since the SCCs are not used in this study, the most direct method to resolve this issue was to minimize the use of the term "source classification code." As a result, the report has been revised and now uses the term "emission source category." Footnote 8 mentions that these source categories are composed of SCCs.

Comment: How significant is the discrepancy between the NEA and DAEMEC estimates of fuel consumption?

Response: The shares of coal, residual fuel oil, distillate fuel oil, and natural gas consumption assigned to industries in Sheets Z, AA, AB, and AC of SIC7090.WK3 do not appear to experience a dramatic change between 1985 (NEA data) and 1986 (DAEMEC data). This is mentioned in footnote 28.