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DOCUMENTATION
OF AIRS AMS
NATIONAL METHODOLOGIES

Prepared for

Prepared by

Air and Energy Engineering Research
Laboratory
Research Triangle Park NC 27711

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DOCUMENTATION OF AIRS AMS

NATIONAL METHODOLOGIES

Final Report

by

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FOREWORD

The document describes the area and mobile source emission estimation procedures that will be used by the national component of the Aerometric Information Retrieval System (AIRS) Area and Mobile Source Subsystem (AMS) to generate emissions estimates for area and mobile source categories for all areas of the U.S. -- non-attainment and attainment. While this document is not one of the official State Implementation Plan (SIP) emission inventory guidance documents being disseminated by EPA's Office of Air Quality Planning and Standards, this does not preclude State and local air agencies from using these methods to estimate their area and mobile source emissions. However, State and local air agencies that wish to use the methods described in this document for purposes of meeting their non-attainment area inventory requirements should first consult with the Chief, Inventory Guidance and Evaluation Section, Emission Inventory Branch, MD-14, Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC 27711.

ABSTRACT

The purpose of this report is to provide States and other participants (e.g., Regional Offices, Headquarters, other Federal agencies) and users of the Area and Mobile Source Subsystem (AMS) with an understanding of the estimation procedures that will be used by the national component of AMS to generate emissions estimates for area and mobile source categories. General methodology and assumptions are discussed as well as the original source of algorithms, activity levels, and emission factors necessary to calculate emissions for each area and mobile source in AMS. This report presents methodologies for all identified sources not defined as point sources. Area and mobile sources are divided into seven major groups, namely, stationary source fuel combustion, mobile sources, industrial processes, solvent utilization, solid waste disposal, natural sources, and miscellaneous area sources. Historically, these methodologies have been referred to as the "National Emissions Data System (NEDS)" methods and to some extent were previously documented in Area Source Documentation for the 1985 National Acid Precipitation Assessment Program Inventory (EPA-600/8-88-106); however, this report did not include certain initial data calculations. In addition, over the years numerous changes have occurred to the sources of the data that "feed" these methodologies. These initial data calculations and source data changes are included in this document.

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ACRONYMS

A	ash
AIRS	Aerometric Information Retrieval System
AMS	Area and Mobile Source Subsystem
AP-42	Compilation of Air Pollutant Emission Factors Vols I & II
CO	carbon monoxide
DOE	United States Department of Energy
DOT	United States Department of Transportation
EPA	United States Environmental Protection Agency
FAA	Federal Aviation Administration
FAP	Federal Aid Primary System
FHWA	Federal Highway Administration
FS	Facility Subsystem
HDDV	Heavy Duty Diesel Vehicles
HDGV	Heavy Duty Gasoline Vehicles
I/M	Inspection/maintenance
IC	internal combustion
LDDT	Light Duty Diesel Trucks
LDDV	Light Duty Diesel Vehicles
LDGT1	Light Duty Gasoline Trucks 1
LDGT2	Light Duty Gasoline Trucks 2
LDGV	Light Duty Gasoline Vehicles
LPG	liquefied petroleum gas
LTOs	landing and takeoff cycles
MC	motorcycles
NEDS	National Emissions Data System
NOAA	National Oceanic and Atmospheric Administration
NO_x	nitrogen oxides
OAQPS	Office of Air Quality Planning and Standards
PAD	Petroleum Administration for Defense District
Pb	lead
PM_{10}	particulate matter ≤ 10 micrometers
SIC	Standard Industrial Classification code
SCC	Source Classification Code
S	sulfur
SO_2	sulfur dioxide
SO_x	sulfur oxides
TIUS	Truck Inventory and Use Survey
TSP	total suspended particulates
VMP	Varnish Makers and Painters
VMT	vehicle miles travelled
VOC	volatile organic compounds

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METRIC CONVERSION FACTORS

Non Metric	Multiplied by	Yields Metric
Acre	4.0469×10^3	Square Meters
Barrels (petroleum, US)	158.98	Liters
Btu	251.83	Calories, Grams
Cubic Feet	0.028317	Cubic Meters
Fahrenheit (°F)	5 / 9 x (°F - 32)	Celsius (°C)
Gallons (US, liquid)	3.7854	Liters
Miles	1.6093	Kilometers
Miles / Gallon	0.4251	Kilometers / Liter
Miles / Hour	1.6093	Kilometers / Hour
Pounds	453.59	Grams
Pounds / 10^6 Cubic Feet	16.015	Kilograms / 10^6 Cubic Meters
Pounds /1000 Gallons	0.1200	Kilograms / 1000 Liters
Pounds / Ton	0.500	Kilograms / Metric Ton
Square Miles	2.590	Square Kilometers
Therms	251.83×10^5	Calories, Grams
Tons (short)	0.9072	Tons
Tons / Acre	224.172	Tons (metric) / Square Mile

SECTION 1

INTRODUCTION

The U.S. Environmental Protection Agency's (EPA's) Office of Air Quality Planning and Standards (OAQPS) in Research Triangle Park, North Carolina, is in the process of developing a nationwide data base of estimated air pollutant emissions from area and mobile sources known as the Aerometric Information Retrieval System (AIRS) Area and Mobile Source Subsystem (AMS).

The purpose of this document is to provide States and other participants and users of AMS (e.g., Regional Offices, Headquarters, other Federal agencies) with an understanding of the estimation procedures that will be used by the national component of AMS to generate emissions estimates for area and mobile source categories. General methodology and assumptions are discussed, as well as the original source of algorithms, activity levels, and emission factors necessary to calculate emissions for each area and mobile source in AMS.

This document presents emission estimation methods for all identified sources not defined as point sources in a specific geographic region. Area sources include all mobile sources, and stationary sources too small, difficult, or numerous to classify as point sources. Area and mobile sources are divided into seven major groups: Stationary Source Fuel Combustion, Mobile Sources, Industrial Processes, Solvent Utilization, Solid Waste Disposal, Natural Sources, and Miscellaneous Area Sources.

Activity levels are derived primarily from related information published by other Federal agencies, supplemented by special data developed by EPA for the purpose of developing AMS emission inventories. Published data such as fuel use by State, motor vehicle miles of travel by State and county, and forest fire acres burned by State are used with related data such as employment, population, and miscellaneous geographic and economic data to derive annual county estimates of the activity levels for each of the AIRS/AMS area source categories. The activity levels derived are adjusted to account for point source activity (such as fuel use by point sources) so that the area source data reflect only the activity levels (and resulting calculated emissions) that are not accounted for by point sources. The source of this point source data is the AIRS Facility Subsystem (FS). Point source emissions data are submitted annually by each State to EPA for inclusion into the AIRS/FS.

Area and mobile source emissions are estimated for the seven criteria pollutants. The seven criteria pollutants are Particulate Matter $\leq$ 10 micrometers (PM_{10}), Total Suspended Particulate (TSP), Sulfur Dioxide (SO_2), Nitrogen Oxides (NO_x), reactive Volatile Organic Compounds (VOCs), Carbon Monoxide (CO), and Lead (Pb). Emissions are calculated for each area and mobile source category utilizing the appropriate emission factors, which are contained in the AMS emission factor file. For many categories, the same emission factors are used for all counties; for some source categories, however, State- or county-specific emission factors account for local variables that affect emissions. The more specific emission factors are used in AMS calculations for all highway motor vehicle categories, fugitive dust categories, and for selected other categories in a few counties where data are available to develop more applicable emission factors than the national emission factors.

Emissions estimates, updated annually by AMS, are conducted by first estimating activity levels for each county and then applying the appropriate emission factor and any applicable control efficiency. County emissions estimates are then summed to produce national emissions estimates.

SECTION 2

BACKGROUND

Historically, the National Emissions Data System (NEDS) has been the computer system the U.S. Environmental Protection Agency (EPA) has used to calculate, store, and retrieve area and mobile source emissions for the following criteria pollutants: TSP, sulfur dioxide (SO_2), NO_x, VOC, and CO. EPA is in the process of designing and developing a new data subsystem in the Aerometric Information and Retrieval System (AIRS) called the Area and Mobile Source Subsystem (AMS) which will replace NEDS.[1]

AMS will use state-of-the-art data base management software with user-friendly menus and screens. The goals of AMS are: 1) provide storage and reporting capabilities for area and mobile source emissions and related data required by EPA regulations and the Clean Air Act; 2) replace the existing system used to store and report these data with a state-of-the-art system; 3) promote information sharing among EPA offices and State and local air agencies; 4) provide the ability to interact with other EPA data bases; and 5) provide enhanced data processing services to the EPA and State and local user community.[1]

With the passage of the Clean Air Act Amendments (CAAA) of 1990 in November 1990, a data system that tracks area and mobile source emissions inventory data becomes critical to the needs of the Agency. In particular, an area and mobile source data system will be needed to support implementation of Title I of the CAAA. This takes the form of 1) storing area and mobile source emissions data as reported by State and local air agencies; and 2) developing comprehensive capabilities to support CAAA regulatory reporting, tracking, and analytical requirements.[1]

Emissions inventory data reported to AMS by State and local air agencies for purposes of supporting Title I of the CAAA involve the reporting of emissions inventory data for nonattainment areas only. AMS, in addition to supporting Title I requirements, will include a "national component" that will include emissions inventory data that may be used for regional modeling purposes. Since regional models require data for both nonattainment and attainment areas and generally require consistent emission estimation methodologies throughout the modeling domain, this "national component" will generate emission estimates using a consistent methodology for area and mobile source categories for all areas of the U.S. -- nonattainment and attainment areas.[1]

In order to accommodate the need to support Title I activities and regional modeling needs, a basic decision has been made to develop AMS using what may be described as a "parallel approach" in that EPA would prepare area and mobile source data for all counties in the U.S. Any State data submitted would reside in "parallel" with the EPA prepared data. As a result of this "parallel approach," AMS will consist of two components -- a national component and a State component.[1]

Ideally, a more integrated or "hybrid" approach would be best. (In the "hybrid approach," EPA would prepare area and mobile source data for all counties in the U.S. Any State data submitted would replace EPA prepared data for source categories in those counties.) However, implementation of the hybrid approach will not be attempted in the base system until: 1) better methodologies are available from emissions inventory research projects currently underway and the States become familiar with an AMS system, and 2) a "plug-in methodology" capability is fully introduced. The emission estimation

procedures that are described in the following sections are the methodologies that will be used within the "national component" of AMS.[1]

Historically, these methodologies have been referred to as the "NEDS" methods and are documented in the following report: Area Source Documentation for the 1985 National Acid Precipitation Assessment Program Inventory.[2] Much of the narrative from that report has been used in the preparation of this document, since the basic concepts for the estimation of the emissions has remained comparable to the methods described in the previous report. Currently, a number of emissions inventory research projects are underway and should provide improved emission estimation procedures. When these new procedures are available, they will be implemented in AMS.

SECTION 3

STATIONARY SOURCE FUEL COMBUSTION

Stationary fuel combustion sources which contribute to area source emissions have been divided into three major categories: Residential Fuel, Commercial and Institutional Fuel, and Industrial Fuel. Collectively, these categories account for all stationary fuel combustion activity not usually reported as point sources. Each category is further subdivided into the following fuel types if appropriate: anthracite coal, bituminous coal, distillate oil, residual oil, natural gas, liquefied petroleum gas (LPG), wood, industrial coke, and process gas. Methodologies for activity level estimation and emission factor derivation are discussed for each category and fuel type.

In the following methodologies for the calculation of activity levels, consumption is determined for each type of fuel using two general steps.

1) County consumption is calculated using an algorithm based on significant variables for which county-specific data are available (e.g., degree days, number of rooms per dwelling, number of dwellings).

2) Resulting county consumption estimates are normalized to reflect published State consumption data by the following equation:

$$NCC = ECC \cdot \frac{PSC}{ESC}$$

where: NCC = Normalized county consumption
ECC = Estimated county consumption
PSC = Published State consumption
ESC = Estimated State consumption (summation of estimated county consumption)

RESIDENTIAL FUEL

The residential fuel category estimates emissions for residential activities which utilize fuel for water heating, space heating, and cooking. Emissions contributed by residential fuel consumption are broken down into six fuel categories including anthracite coal, bituminous coal, distillate oil, natural gas, LPG, and wood. Emissions from the residential residual oil consumption category are considered to be negligible; therefore, no method exists for this category. For each of the listed fuel types, activity levels measured by fuel quantity consumed in weight or volume units are multiplied by emission factors to obtain emissions estimates. Methodologies for activity levels and emission factors are presented below.

Anthracite Coal

The basic methodology for allocating residential consumption of anthracite coal to individual counties involves the use of an algorithm which relates coal consumption to the number of dwelling units and heating degree days. Adjustments are made to housing data to account for secular trends in the number of coal-heated dwelling units, then the results are normalized as necessary in the steps below.

1) Variables found to be significant by regression analyses were the number of occupied dwelling units in the county using coal for space heating and the annual heating degree days for the county. Dwelling unit data from the latest census are updated using a regional growth factor which reflects the number of dwellings currently using coal for space heating purposes.[3]

2) The number of dwelling units is obtained from the Census Bureau's decennial Census of Housing.[4] Estimates of dwelling units by census region using a particular type of fuel for space heating purposes for years between the decennial census are found in the Census Bureau's biennial American Housing Survey.[5] The number of annual heating degree days per county is taken from National Oceanic and Atmospheric Administration's (NOAA's) Climatological Data.[6] Published State residential anthracite coal consumption is determined from the U.S. Department of Energy's (DOE's) State Energy Data Report.[7]

Anthracite Coal Equations –

A normalized estimate of County Residential Anthracite Consumption (NCRA) (in short tons) is produced by the execution of the following equations:

$$NCRA = \frac{ECA}{\sum_{n=1}^{c} ECA_n} \cdot SRA$$

where: NCRA = Normalized county anthracite coal consumption by residential sources
ECA = Estimated county residential anthracite coal consumption
SRA = Published State total of residential anthracite coal consumption in short tons
c = Number of counties in State

ECA is computed using the formula:

$$ECA = 0.00387 \cdot UCH \cdot e^{\left(7.64 - \frac{1000}{DD}\right)}$$

where: UCH = Number of occupied dwelling units in county using coal heat in current year (computed below)
DD = Annual heating degree days in county

UCH is computed using the formula:

$$UCH = CCH \cdot \frac{RCH}{\sum_{n=1}^{s} SCH_n}$$

where: CCH = County housing units using coal heat in census year
RCH = Regional housing units using coal heat in current year
s = Number of States in census region
SCH = State housing units using coal heat in census year

Anthracite Coal Emission Factors --

Emission factors for anthracite use in hand-fired boilers are taken directly from AP-42, Table 1.2-1.[8] For the purposes of this calculation, ash content value and sulfur content value are assumed to be 11 percent and 0.7 percent, respectively.[9] Since there is only one anthracite coal producing district in the U.S. and the sulfur and ash contents are relatively uniform, this assumption appears reasonable.

Bituminous Coal

The basic methodology for allocating residential consumption of bituminous coal to individual counties involves the use of an algorithm which relates coal consumption to the number of dwelling units and heating degree days. Adjustments are made to housing data to account for secular trends in the number of coal-heated dwelling units. The results are then normalized as necessary in the steps below.

1) Variables found to be significant by regression analyses were the number of occupied dwelling units in the county using coal for space heating and the annual heating degree days for the county. Dwelling unit data from the latest census are updated using a regional growth factor which reflects the number of dwellings currently using coal for space heating purposes.[3]

2) The number of dwelling units is obtained the Census Bureau's decennial Census of Housing.[4] Estimates of dwelling units by census region using a particular type of fuel for space heating purposes for years between the decennial census are found in the Census Bureau's biennial American Housing Survey.[5] The number of annual heating degree days per county is taken from NOAA's Climatological Data.[6] Published State residential bituminous coal consumption is determined from the DOE State Energy Data Report.[7]

Bituminous Coal Equations --

A normalized estimate of County Residential Bituminous Consumption (NCRB) (in short tons) is produced by the execution of the following equations:

$$NCRB = \frac{ECB}{\sum_{n=1}^{c} ECB_n} \cdot SRB$$

where: NCRB = Normalized county bituminous coal consumption by residential sources
ECB = Estimated county residential bituminous coal consumption
SRB = Published State total of residential bituminous coal consumption in short tons
c = Number of counties in State

ECB is computed using the formula:

$$ECB = 0.00387 \cdot UCH \cdot e^{\left(7.64 - \frac{1000}{DD}\right)}$$

where: UCH = Number of occupied dwelling units in county using coal heat in current year (computed below)
DD = Annual heating degree days in county

UCH is computed using the formula:

$$UCH = CCH \cdot \frac{RCH}{\sum_{n=1}^{s} SCH_n}$$

where: CCH = County housing units using coal heat in census year
RCH = Regional housing units using coal heat in current year
s = Number of States in census region
SCH = State housing units using coal heat in census year

Bituminous Coal Emission Factors --

The emission factors for hand-fired units are obtained from AP-42, Table 1.1-1.[8] For SO_2, the average sulfur content is the weighted average of the sulfur content of each production district from Coal Production.[9] District averages are then weighted according to shipment data for each 'district to destination' ("Other Consumers") contained in the DOE document Coal Distribution.[10] This methodology is described in detail in the section on Sulfur Content.

Distillate Oil

Consumption of distillate oil by residential sources is determined by allocating State consumption to the county level using housing data. Total county residential consumption is calculated as the sum of distillate oil used for space heating and other purposes for the most recent census year and then normalized with total State consumption.

Incorporation of EPA factors along with other variables and performance of a regression analysis yields an algorithm which determines county consumption of fuel for space and water heating using the annual heating degree days and the median number of rooms of occupied dwelling units for each county.[11] Distillate oil not used for space heating purposes is estimated by assuming that each housing unit utilizes 250 gallons of oil per year for hot water heating purposes.

The number of annual heating degree days in each county is found in NOAA's Climatological Data.[6] The median number of rooms per dwelling unit in each county is obtained from the Census Bureau's decennial Census of Housing.[4] State distillate oil delivery data (adjusted sales) are available in DOE's Fuel Oil and Kerosene Sales report.[12] Though the Fuel Oil and Kerosene Sales publication does not report consumption, the AMS methodology assumes the adjusted sales (delivery) data equate to consumption.

Distillate Oil Equations --

A normalized estimate of County Residential Distillate Oil Consumption (NCO) (in 1000 gallons) is produced by the execution of the following equations:

$$NCO = \frac{CRDO}{\sum_{n=1}^{c} CRDO_n} \cdot STRD$$

where: NCO = Normalized county distillate oil consumption by residential sources
CRDO = Estimated county residential distillate oil consumption
STRD = Published State total of residential distillate oil consumption in 1000 gallons (computed below)
c = Number of counties in State

CRDO is computed using the formula:

$$CRDO = \frac{\left(\frac{0.01288 \cdot DD + 30.14 \cdot MR - 79.54}{0.14}\right) \cdot UOH + 250 \cdot UOW}{1000}$$

where: DD = Annual heating degree days in county
MR = Median number of rooms per dwelling units in the county
UOH = Number of occupied dwelling units in county using oil heat in current year (computed below)
UOW = Number of occupied dwelling units in county using oil for water heating in census year

STRD is computed using the formula:

STRD	=	State Residential Distillate # 1	+
		State Residential Distillate # 2	+
		State Residential Kerosene	

UOH is computed using the formula:

$$UOH = COH \cdot \frac{ROH}{\sum_{n=1}^{s} SOH_n}$$

where:	COH	=	County housing units using oil heat in census year
	ROH	=	Regional housing units using oil heat in current year
	s	=	Number of States in census region
	SOH	=	State housing units using oil heat in census year

Distillate Oil Emission Factors --

Emission factors are taken directly from AP-42, Table 1.3-1.[8] For the SO_2 factor, average sulfur content values for No. 1 and No. 2 fuel oils reported in Heating Oils[13] are weighted by corresponding deliveries to residential users found in the DOE report Fuel Oil and Kerosene Sales.[12]

Natural Gas

In the AMS inventory, residential natural gas consumption is defined as the sum of natural gas consumption for the purposes of cooking, water heating, and space heating. In general, the methodology is designed to produce county consumption estimates for each use by fuel type and to normalize the county estimates with published data. More detailed descriptions of the methodologies used for the estimation of natural gas consumption are discussed below.

The methodology for determining residential natural gas consumption consists of performing a series of calculations to update census data so that they can be input into an algorithm which computes consumption. The final result is then normalized by comparing it to published State data.

Regression analysis was utilized to develop an algorithm which calculated natural gas consumption based on annual heating degree days, the number of occupied dwelling units using gas for cooking or water heating fuel, and the median number of rooms per dwelling.[3]

The number of occupied dwelling units in the county using gas for space heating in the current year is determined using the number of dwellings with gas heat in the census year, updated to include the increase in the number of gas heating dwellings since the census year. The increase in the number of gas heated dwellings per county is estimated by summing (1) the number of additional gas heated dwellings in the State due to new housing starts -- distributed to the county level by population -- and (2) the number of conversions to gas space heating in the State since the census year, distributed to the county level by the proportion of dwelling units using gas heat in the census year.

An estimate of the number of occupied dwelling units in the county using gas for all purposes in

the current year is computed by dividing the updated number of gas heated dwellings by the percentage of residential gas customers known to have gas heat from gas utility statistics.

The number of dwellings using gas for all purposes is input with heating degree days and the median number of rooms per dwelling into an algorithm which yields county estimates of natural gas consumption. County estimates are then totalled and compared with published State residential consumption figures.

Annual heating degree days are taken from NOAA's Climatological Data.[6] The number of dwellings using natural gas for space heating and water heating per county is available in the Census of Housing.[4] The median number of rooms per dwelling is obtained from the Census Bureau's decennial Census of Housing.[4] The percentage of residential customers using gas for space heating, and residential gas heat conversions and heating unit additions data are found in the Gas House Heating Survey.[14] The current county population is found in the Census Bureau's Current Population Reports.[15] The average regional natural gas consumption is obtained from Gas Facts[16], and residential natural gas consumption data are taken from the Natural Gas Annual.[17]

Natural Gas Equations --

A normalized estimate of County Residential Natural Gas Consumption (NCG) (millions of cubic feet) is produced by the execution of the following equations:

$$NCG = \frac{ECG}{\sum_{n=1}^{c} ECG_n} \cdot SNG$$

where: NCG = Normalized county natural gas consumption by residential sources
ECG = Estimated county residential natural gas consumption (computed below)
SNG = Published State total of residential natural gas consumption (million cubic feet)
c = Number of counties in State

ECG is computed using the formula:

$$ECG = 47.5 \cdot UG \cdot DD^{0.367} \cdot \left[\frac{UGH}{UX}\right]^{0.588} \cdot MR^{0.125}$$

where: UG = Number of occupied dwelling units in county using piped gas in current year
DD = Annual heating degree days in county
UGH = Number of occupied dwelling units in county using gas heat in census year
UX = Number of occupied dwelling units in county using gas for cooking or hot water fuel in census year, whichever is larger
MR = Median number of rooms per dwelling units in the county

UG is computed using the formula:

$$UG = \frac{CGH}{RPH}$$

where: CGH = Number of occupied dwelling units in county using gas heat in current year (computed below)
RPH = Percentage of residential gas customers in State with gas heat

CGH is computed using the equation:

$$CGH = UGH + IGH$$

where: UGH = Number of occupied dwelling units in county using gas heat in census year
IGH = Total increase since census year in county dwelling units using gas for space heating (computed below)

IGH is computed using the equation:

$$IGH = \left(\frac{CPC}{\sum_{n=1}^{c} CPC_n} \cdot A \right) + \left(\frac{UGH}{SGH} \cdot C \right)$$

where: CPC = Growth in county population since census year (computed below)
A = Number of additional gas-heated dwelling units in State due to new housing starts since census year
UGH = Number of occupied dwelling units in county using gas heat in census year
SGH = Number of occupied dwelling units in State using gas heat in census year
C = Number of conversions to gas space heating in the State since census year
c = Number of counties in State

CPC is computed using the equation:

$$CPC = CP - CCP$$

NOTE: If CP - CCP < 0, then CPC = 0.

where: CP = Current county population
CCP = County population in most recent census year

Natural Gas Emission Factors --

Emission factors for natural gas consumption are obtained from AP-42, Table 1.4-1.[8]

LPG

In the AMS inventory, residential LPG consumption is defined as the LPG consumption for the purposes of cooking, water heating, and space heating. In general, the methodology is designed to produce county consumption estimates for each use by fuel type, and normalize the county estimates with published LPG consumption data. More detailed descriptions of the methodologies used for the estimation of LPG consumption are discussed below.

County residential consumption of LPG is approximated by an algorithm using county annual heating degree days, the number of occupied dwelling units in the county using LPG for space heating, water heating and cooking fuel in the county, and the average regional consumption by water heaters and cooking ranges.[3]

Annual heating degree days are taken from NOAA's Climatological Data.[6] The number of occupied dwelling units in the county using LPG for space heating and water heating is available from the Census of Housing.[4] Average regional consumption data are obtained from Gas Facts.[16] Residential LPG consumption information is found in the State Energy Data Report.[7]

LPG Equations --

A normalized estimate of County Residential LPG Consumption (NCL) (in 1000 gallons) is produced by the execution of the following equations:

$$NCL = \frac{ECL}{\sum_{n=1}^{c} ECL_n} \cdot SRL \cdot 42$$

where: NCL = Normalized county LPG consumption by residential sources
ECL = Estimated county residential LPG consumption (computed below)
SRL = Published State total of residential LPG consumption in 1000 barrels
42 = Factor to convert barrels to gallons
c = Number of counties in State

ECL is computed using the formula:

$$ECL = 0.00105 \cdot CLT$$

where: CLT = Estimated county residential LPG consumption in therms (computed below)

NOTE: 0.00105 is the factor used to convert therms to thousands of gallons of LPG

CLT is computed using the formula:

$$CLT = (376 + 0.209DD) \cdot ULH + (RAW \cdot ULW) + (RAC \cdot ULC)$$

where:
- DD = Annual heating degree days in county
- ULH = Number of occupied dwelling units in county using LPG for space heating in current year (computed below)
- RAW = Average regional consumption (therms/year) of gas by water heaters
- ULW = Number of occupied dwelling units in county using LPG for water heating in census year
- RAC = Average regional consumption (therms/year) of gas by cooking ranges
- ULC = Number of occupied dwelling units in county using LPG as cooking fuel in census year

ULH is computed using the equation:

$$ULH = CLH \cdot \frac{RLH}{\sum_{n=1}^{s} SLH_n}$$

where:
- CLH = Number of occupied dwelling units in county using LPG for space heating in census year
- RLH = Number of occupied dwelling units in census region using LPG for space heating in current year
- s = Number of States in census region
- SLH = Number of occupied dwelling units in State using LPG for space heating in census year

Census publications report housing units using bottled gas for space heating. For purposes of AMS calculations, bottled gas is assumed to equate to LPG.

LPG Emission Factors --

Emission factors for LPG combustion are obtained from AP-42, Table 1.5-1.[8]

Wood

In the AMS inventory, residential wood consumption is defined as the wood consumption for the purposes of space heating. In general, the methodology is designed to produce county consumption estimates and normalize the county estimates with published wood consumption data. More detailed descriptions of the methodologies used for the estimation of wood consumption are discussed below.

County residential consumption of wood is allocated to counties by an algorithm using county annual heating degree days and the number of occupied dwelling units in the county using wood for space heating.

Annual heating degree days are taken from NOAA's Climatological Data.[6] The number of occupied dwelling units in the county using wood for space heating is available from the Census of Housing.[4] Residential wood consumption information is found in the Estimates of U.S. Wood Energy Consumption[18] and the Household Energy Consumption and Expenditures.[19]

The original State estimates presented in DOE's Estimates of U.S. Wood Energy Consumption[18] are updated annually using regional wood consumption estimates reported in the Household Energy Consumption and Expenditures[19] and regional estimates of dwelling units using wood for space heating purposes as reported in the American Housing Survey.[5]

Wood Equations –

An estimate of County Residential Wood Consumption (CRW) (in short tons) is calculated using the following equations:

If State data exist, then use the following equation:

$$CRW = \frac{\left(\frac{UWH}{SWH} + \frac{DD}{SDD}\right)}{\sum_{n=1}^{c}\left(\frac{UWH_n}{SWH_n} + \frac{DD_n}{SDD_n}\right)} \cdot SRW$$

If regional data exist, then use the following equation:

$$CRW = \frac{\left(\frac{UWH}{SWH} + \frac{DD}{SDD}\right)}{\sum_{n=1}^{c}\left(\frac{UWH_n}{SWH_n} + \frac{DD_n}{SDD_n}\right)} \cdot SRW_p \cdot \frac{RRW}{\sum_{n=1}^{s} SRW_{pn}}$$

where:

CRW	=	Normalized county residential wood consumption
UWH	=	Number of occupied housing units in county using wood for space heating in current year (computed below)
SWH	=	Number of occupied housing units in county using wood for space heating
DD	=	Annual heating degree days in county
SDD	=	Annual heating degree days in State
SRW	=	Reported State residential wood consumption in current year
SRW_p	=	Reported State residential wood consumption in previous year
RRW	=	Reported regional residential wood consumption in current year
c	=	Number of counties in the State
s	=	Number of States in the region

UWH is computed using the equation:

$$UWH = CWH \cdot \frac{RWH}{\sum_{n=1}^{s} SWH_n}$$

where: CWH = Number of occupied dwelling units in county using wood for space heating in census year
RWH = Number of occupied dwelling units in census region using wood for space heating in current year
s = Number of States in region
SWH = Number of occupied dwelling units in State using wood for space heating in census year

Wood Emission Factors --

Emission factors for woodstoves and fireplaces from AP-42, Tables 1.9-1 and 1.10-1[8] are weighted based on the proportions of wood burned in woodstoves and in fireplaces.

Weighting is accomplished by performing a series of calculations on computed wood consumption estimates which includes: (1) estimating the number of stoves based on shipments and imports from Estimates of U.S. Wood Energy Consumption,[18] (2) calculating an obsolescence rate to determine the total stove inventory in current use, and (3) determining the stove population in primary and secondary use based on the number of dwellings units using wood heat as found in the American Housing Survey.[5] Stove efficiency is also taken into account.

COMMERCIAL AND INSTITUTIONAL FUEL

Area source emissions from fuel use by commercial and institutional sources consist of emissions from all fuel burned in stationary sources that are not included under residential sources, industrial sources, power plants, or commercial point sources. Examples of commercial/institutional area sources are hospitals, hotels, laundries, schools, and universities. Fuel types included in the discussion of activity levels and emission factors are anthracite coal, bituminous coal, distillate oil, residual oil, natural gas, LPG, and wood.

Activity levels are estimated for anthracite coal, bituminous coal, distillate oil, residual oil, natural gas, LPG and wood. Currently, AMS does not employ a methodology to estimate wood fuel consumption by commercial/institutional sources. Emissions from this source are considered negligible compared to those from other sources.

Anthracite Coal

The county commercial/institutional area source activity level of anthracite coal is calculated by first determining State total commercial/institutional area source anthracite coal consumption and allocating this area source coal consumption to counties via county and State commercial employment figures.

Commercial/institutional anthracite coal consumption is found in DOE's State Energy Data Report.[7] Consumption of anthracite coal by commercial/institutional point sources is obtained from AIRS/FS Point Source Data Files. Employment data are obtained from either the Census Bureau's Census of Manufacturers[21] (quinquennial) or the Census Bureau's County Business Patterns[22] (annual).

Anthracite Coal Equations --

An estimate of County Commercial Anthracite Coal (CAC) (in short tons) is calculated as follows:

$$CAC = SACAC \cdot \frac{CCE}{SCE}$$

where: CAC = Estimated county anthracite coal consumption by commercial sources
SACAC = State commercial area source anthracite coal consumption (computed below)
CCE = County employment for SICs 50 through 97
SCE = State employment for SICs 50 through 97

SACAC is computed as follows:

$$SACAC = STCAC - PTCAC$$

NOTE: If SACAC < 0, then set SACAC = 0.

where: STCAC = Published State total commercial anthracite coal consumption
PTCAC = State commercial point source anthracite coal consumption (computed below)

PTCAC is computed as follows:

$$PTCAC = \sum_{n=1}^{s} APCS_n$$

where: s = AIRS Facility points for SCC 1-03-001-**
APCS = Annual throughput at commercial point sources in the AIRS/FS Point Source Data Files[20] summed by State

NOTE: The double asterisk "**" indicates a series of SCCs belonging to a general group. For example, the general group represented by 1-03-001-** indicates that several different boiler types may be found within this series.

Anthracite Coal Emission Factors --

Emission factors are obtained from AP-42, Table 1.2-1[8] for the boiler types listed for SCC 1-03-001-** in the AIRS/FS Point Source Data Files.[20] The emission factors are then combined by weighting each factor in proportion to the total AIRS/FS anthracite coal consumption of each boiler type. For the purpose of this calculation, it is assumed that ash content is 11 percent and that sulfur content is 0.7 percent.[9]

Bituminous Coal

The county commercial/institutional area source activity level of bituminous coal is calculated by first determining State total commercial/institutional area source bituminous coal consumption and then allocating this area source coal consumption to counties via county and State commercial employment figures.

Commercial/institutional bituminous coal consumption is found in DOE's State Energy Data Report[7]. Consumption of bituminous coal by commercial/institutional point sources is obtained from AIRS/FS Point Source Data Files.[20] Employment data are obtained from either the Census Bureau's Census of Manufacturers[21] (quinquennial) or the Census Bureau's County Business Patterns[22] (annual).

Bituminous Coal Equations --

An estimate of County Commercial Bituminous Coal Consumption (CBC) (in short tons) is calculated as follows:

$$CBC = SACBC \cdot \frac{CCE}{SCE}$$

where: CBC = Estimated county bituminous coal consumption by commercial sources
SACBC = State commercial area source bituminous coal consumption (computed below)
CCE = County employment for SICs 50 through 97
SCE = State employment for SICs 50 through 97

SACBC is computed as follows:

$$SACBC = STCBC - PTCBC$$

NOTE: If SACBC < 0, then set SACBC = 0.

where: STCBC = Published State total commercial bituminous coal consumption
PTCBC = State commercial point source bituminous coal consumption (computed below)

PTCBC is computed as follows:

$$PTCBC = \sum_{n=1}^{s} BPCS_n$$

where: s = AIRS Facility points for source classification codes
1-03-002-**
1-03-003-**

BPCS = Annual throughput at commercial point source classification codes in the AIRS/FS Point Source Data Files[20] summed by State

Bituminous Coal Emission Factors –

Weighted emission factors for boilers are obtained using emission factors from AP-42, Table 1.1-1[8] and coal consumption from AIRS/FS Point Source Data Files[20] for SCC 1-03-002-** and 1-03-003-**. Average sulfur content value is determined by weighted average of the sulfur content of each production district found in Coal Production.[9] District averages are then weighted according to shipment data for each 'district to destination' ("Other Consumers") contained in DOE's Coal Distribution.[10]

Distillate Oil

The county commercial/institutional area source activity level of distillate oil is calculated by first determining State total commercial/institutional area source distillate oil consumption and allocating this area source oil consumption to counties via county and State commercial employment figures.

Commercial/institutional distillate oil deliveries (adjusted sales) are found in DOE's Fuel Oil and Kerosene Sales report.[12] The Fuel Oil and Kerosene Sales publication does not report consumption. However, the AMS methodology assumes that the delivery (adjusted sales) data equate to consumption. Consumption of distillate oil by commercial/institutional point sources is obtained from AIRS/FS Point Source Data Files[20]. Employment data are obtained from either the Census Bureau's Census of Manufacturers[21] (quinquennial) or the Census Bureau's County Business Patterns[22] (annual).

Distillate Oil Equations –

An estimate of County Commercial Distillate Oil Consumption (CDO) (in 1000 gallons) is calculated as follows:

$$CDO = SACDO \cdot \frac{CCE}{SCE}$$

where: CDO = Estimated county distillate oil consumption by commercial sources

SACDO = State commercial area source distillate oil consumption (computed below)

CCE = County employment for SICs 50 through 97

SCE = State employment for SICs 50 through 97

SACDO is computed as follows:

$$SACDO = STCDO - PTCDO$$

NOTE: If SACDO < 0, then set SACDO = 0.

where: STCDO = Published State total commercial distillate oil consumption
PTCDO = State commercial point source distillate oil consumption

STCDO is computed as follows:

STCDO = State Commercial Distillate # 1 +
State Commercial Distillate # 2 +
State Commercial Distillate # 4 +
State Commercial Kerosene +
State Farm Use: Other Distillate +
State Farm Use: Kerosene +
State Military: Other Distillate

PTCDO is computed as follows:

$$PTCDO = \sum_{n=1}^{SCC} DPCS_n$$

where: SCC = AIRS Facility points for SCCs 1-03-005-** and 2-03-001-**
DPCS = Annual throughput at commercial point sources in the AIRS/FS Point Source Data Files[20] summed by State

Distillate Oil Emission Factors --

Emission factors are taken directly from AP-42, Table 1.3-1.[8] For SO_2, average sulfur content values for No. 1, No. 2, and No. 4 oils from Heating Oils[13] are weighted using commercial deliveries (adjusted sales) by oil type as reported in the Fuel Oil and Kerosene Sales[12] report.

Residual Oil

The county commercial/institutional area source activity level of residual oil is calculated by first determining State total commercial/institutional area source residual oil consumption and then allocating this area source oil consumption to counties via county and State commercial employment figures.

Commercial/institutional residual oil deliveries (adjusted sales) are found in DOE's Fuel Oil and Kerosene Sales[12] report. The Fuel Oil and Kerosene Sales publication does not report consumption. However, the AMS methodology assumes that the delivery (adjusted sales) data equate to consumption. Consumption of residual oil by commercial/institutional point sources is obtained from

AIRS/FS Point Source Data Files[20]. Employment data are obtained from either the Census Bureau's Census of Manufacturers[21] (quinquennial) or the Census Bureau's County Business Patterns[22] (annual).

Residual Oil Equations –

An estimate of County Commercial Residual Oil Consumption (CRO) (in 1000 gallons) is calculated as follows:

$$CRO = SACRO \cdot \frac{CCE}{SCE}$$

where: CRO = Estimated county residual oil consumption by commercial sources
SACRO = State commercial area source residual oil consumption (computed below)
CCE = County employment for SICs 50 through 97
SCE = State employment for SICs 50 through 97

SACRO is computed as follows:

$$SACRO = STCRO - PTCRO$$

NOTE: If SACRO < 0, then set SACRO = 0.

where: STCRO = Published State total commercial residual oil consumption
PTCRO = State commercial point source residual oil consumption (computed below)

STCRO is computed as follows:

STCRO = State Commercial Residual Oil + State Military Residual Oil

PTCRC is computed as follows:

$$PTCRO = \sum_{n=1}^{s} RPCS_n$$

where: s = AIRS Facility points for SCC 1-03-004-**
RPCS = Annual throughput at commercial point sources in the AIRS/FS Point Source Data Files[20] summed by State

Residual Oil Emission Factors --

Emission factors are taken directly from AP-42, Table 1.3-1.[8] Sulfur content values are obtained for No. 5 light, No. 5 heavy, and No. 6 fuel oils in Heating Oils.[13] A weighted average is calculated using No. 6 sulfur content and for the mean of No. 5 oil sulfur contents, assuming 13 percent and 87 percent of the fuel oil used is No. 5 and No. 6, respectively.

Natural Gas

The county commercial/institutional area source activity level of natural gas is calculated by first determining State total commercial/institutional area source natural gas consumption and allocating this area source oil consumption to counties via county and State commercial employment figures.

Commercial/institutional natural gas consumption is found in DOE's report entitled Natural Gas Annual.[17] Consumption of natural gas by commercial/institutional point sources is obtained from AIRS/FS Point Source Data Files.[20] Employment data are obtained from either the Census Bureau's Census of Manufacturers[21] (quinquennial) or the Census Bureau's County Business Patterns[22] (annual).

Natural Gas Equations --

An estimate of County Commercial Natural Gas Consumption (CNG) (million cubic feet) is calculated as follows:

$$CNG = SACNG \cdot \frac{CCE}{SCE}$$

where:
- CNG = Estimated county natural gas consumption by commercial sources
- SACNG = State commercial area source natural gas consumption (computed below)
- CCE = County employment for SICs 50 through 97
- SCE = State employment for SICs 50 through 97

SACNG is computed as follows:

$$SACNG = STCNG - PTCNG$$

NOTE: If SACNG < 0, then set SACNG = 0.

where:
- STCNG = Published State total commercial natural gas consumption
- PTCNG = State commercial point source natural gas consumption (computed below)

PTCNG is computed as follows:

$$PTCNG = \sum_{n=1}^{s} NGPCS_n$$

where: s = AIRS Facility points for SCCs
1-03-006-**
2-03-002-**

NGPCS = Annual throughput at commercial point sources in the AIRS/FS Point Source Data Files[20] summed by State

Natural Gas Emission Factors –

Emission factors for natural gas are obtained directly from AP-42, Table 1.4-1.[8]

LPG

The county commercial/institutional area source activity level of LPG is calculated by first determining State total commercial/institutional area source LPG consumption and allocating this area source oil consumption to counties via county and State commercial employment figures.

Commercial/institutional LPG consumption is found in DOE's State Energy Data Report.[7] Consumption of LPG by commercial/institutional point sources is obtained from AIRS/FS Point Source Data Files.[20] Employment data are obtained from either the Census Bureau's Census of Manufacturers[21] (quinquennial) or the Census Bureau's County Business Patterns[22] (annual).

LPG Equations –

An estimate of County Commercial LPG Consumption (CLG) (1000 gallons) is calculated as follows:

$$CLG = SACLP \cdot \frac{CCE}{SCE}$$

where: CLG = Estimated county LPG consumption by commercial sources
SACLP = State commercial area source LPG consumption (computed below)
CCE = County employment for SICs 50 through 97
SCE = State employment for SICs 50 through 97

The formula to compute (SACLP) is:

$$SACLP = [STCLP \cdot 42] - PTCLP$$

NOTE: If SACLP < 0, then set SACLP = 0.

where: STCLP = Published State total commercial LPG consumption
PTCLP = State commercial point source LPG consumption (computed below)

PTCLP is computed using the equation:

$$PTCLP = \sum_{n=1}^{s} LPPCS_n$$

where: s = AIRS Facility points for source classification codes
1-03-010-**
2-03-010-**
LPPCS = Annual throughput at commercial point sources in the AIRS/FS Point Source Data Files[20] summed by State

LPG Emission Factors --

Emission factors for LPG are obtained directly from AP-42, Table 1.5-1.[8]

Wood

No methodology has been developed for commercial/institutional wood use. Emissions from this source are considered negligible compared to those from other area sources.

INDUSTRIAL FUEL

Area source emissions generated by the industrial fuel consumption sector which are not accounted for by point source categories are discussed for the following fuel types: anthracite coal, bituminous coal, distillate oil, residual oil, natural gas, LPG, wood, industrial coke, and process gas. Methodologies for consumption and emission factor computation are presented as available.

A procedure was developed for the allocation of State industrial area source consumption of bituminous coal, distillate oil, residual oil, natural gas, and LPG.[3,11] The procedure for estimating industrial bituminous coal area source consumption has been adjusted and applied to estimating industrial anthracite coal area source consumption. Originally, the procedure for industrial natural gas consumption called for the inclusion of industrial LPG consumption. LPG will now be estimated on a separate basis. In addition, industrial natural gas consumption at boilers and industrial natural gas consumption at internal combustion (IC) engines will be estimated on a separate basis.

Procedures for estimating coke, wood, and process gas activity levels have not been developed. Industrial area source consumption of these fuels is assumed to be negligible.

Anthracite Coal

The methodology for determining anthracite coal consumption by industrial area sources consists of two steps. County industrial fuel consumption for anthracite coal is calculated on a county basis, where county values are summed and then normalized with the State published value.[3] Sources of inputs and normalization are discussed below.

The first step in the methodology is to determine industrial anthracite coal consumption by county. This is accomplished by adjusting county area source employment figures for SIC categories 20 through 39 by a fuel intensity factor. For the purpose of this calculation, county area source employment is defined as the difference between total county employment and point source employment for each SIC category. The fuel intensity ratio is a measure of fuel use intensity per employee, which is determined by dividing the State consumption of fuel -- in this case anthracite coal -- for each SIC category by the respective State employment. (If State data are not available, regional data are used. If regional data are not available, national data are used.) County area source consumption is then summed for all counties to obtain State area source consumption for anthracite coal.

County consumption values are then normalized to agree with the State level calculated industrial area source consumption values for anthracite coal. Reported industrial area source consumption is calculated by subtracting the point source industrial anthracite coal consumption as reported to AIRS/FS from the published State total anthracite coal consumption.

Sources of information on county total and point source employment figures for SIC categories 20 through 39 are obtained from the Census Bureau's County Business Patterns.[22] Total industrial coal consumption for States for each year is found in DOE's State Energy Data Report[7] and industrial coal shipments for States for each year are found in DOE's Coal Distribution: January-December report.[10] Information concerning consumption of bituminous coal by SIC category is found in DOE's Manufacturing Energy Consumption Survey[23] and is used to calculate fuel intensity factors. State industrial point source data are taken directly from AIRS/FS Point Source Data Files.[20]

Anthracite Coal Equations --

A normalized estimate of County Industrial Anthracite Coal Consumption (NCIA) (in short tons) is computed using the formula:

$$NCIA = CIF_4 \cdot \frac{SIA}{\sum_{n=1}^{c} CIF_{4,n}}$$

where: NCIA = Normalized county industrial anthracite coal consumption
CIF_4 = Estimated county anthracite consumption by industrial sources (computed below)
SIA = Reported State industrial area source anthracite coal consumption (computed below)
c = Number of counties in State

SIA is computed using the formula:

$$SIA = SOIA - SPA$$

If SIA < 0, then set SIA = 0.

where: SOIA = Total State industrial anthracite coal consumption (computed below)

SPA = State industrial point source anthracite coal consumption (computed below)

SPA is computed using the formula:

$$SPA = \sum_{n=1}^{SCC} APIS_n$$

where: SCC = AIRS Facility points for SCCs 1-02-001-** and 3-90-001-**
APIS = Annual throughput at industrial point sources in the AIRS/FS Point Source Data Files[20] summed by State

SOIA is computed using the formula:

$$SOIA = TSA \cdot \frac{SSIA}{SSIA + SSCA}$$

where: TSA = Published State total industrial anthracite coal consumption
SSIA = Published total of anthracite shipments to "other industrial" users by State
SSCA = Published total of anthracite shipments to coke plants by State

An estimate of County Industrial Anthracite Fuel consumption (CIF_4) is derived with the following formula:

$$CIF_4 = \sum_{j=1}^{SIC} CAE_j \cdot FIR_{4j}$$

where: CIF_4 = Estimated county industrial anthracite fuel consumption
SIC = SIC codes 20 through 39
CAE_j = County area source employment for SIC_j
FIR_{4j} = State fuel intensity ratio -- a measure of fuel use intensity per employee for anthracite coal by SIC category j

CAE_j is computed using the formula:

$$CAE_j = TCE_j - CPE_j$$

where: TCE_j = Total employment in county for SIC category j
CPE_j = Point source employment in county for SIC category j

State fuel intensity ratio (FIR_{4j}) is computed using the formula:

$$FIR_{4J} = \frac{F_{4J}}{E_J}$$

where: $F4_j$ = State consumption of anthracite coal by SIC category j
E_j = Total employment in State for SIC category j in year of most recent Census of Manufacturers

NOTE: If input data are not available to compute **State** fuel intensity ratios, then RFR_{4j} is substituted for FIR_{4j} in the formula used to compute estimates of **county** industrial anthracite fuel consumption CIF_4. In this case the formula used is:

$$CIF_{4J} = \sum_{J=1}^{SIC} CAE_J \cdot RFR_{4J}$$

where: RFR_{4j} = Regional fuel intensity ratio for anthracite coal by SIC category j (computed below)

RFR_{4j} is computed using the formula:

$$RFR_{4J} = \frac{RF_{4J}}{RE_J}$$

where: RF_{4j} = Regional consumption of anthracite coal by SIC category j
RE_j = Total employment in census region for SIC category j in year of most recent Census of Manufacturers

NOTE: If input data are not available to compute **regional** fuel intensity ratios, then NFR_{4j} is substituted for RFR_{4j} in the formula used to compute estimates of **county** industrial anthracite fuel consumption CIF_4. In this case the formula used is:

$$CIF_{4J} = \sum_{J=1}^{SIC} CAE_J \cdot NFR_{4J}$$

where: NFR_{4j} = National fuel intensity ratio for anthracite coal by SIC category j (computed below)

NFR_{4j} is computed using the formula:

$$NFR_{4j} = \frac{NF_{4j}}{NE_j}$$

where: NF_{4j} = National consumption of anthracite coal by SIC category j
NE_j = Total employment in nation for SIC category j in year of most recent Census of Manufacturers

Anthracite Coal Emission Factors --

Emission factors are obtained from AP-42, Table 1.2-1[8] for the boiler types listed for SCCs 1-02-001-** and 3-90-001-** in the AIRS/FS Point Source Data Files[20] files. The emission factors are then combined by weighting each factor in proportion to the total AIRS/FS anthracite coal consumption of each boiler type. For the purpose of this calculation, it is assumed that ash content is 11 percent, and that sulfur content is 0.7 percent.[9]

Bituminous Coal

The methodology for determining bituminous coal consumption by industrial area sources consists of two steps. County industrial fuel consumption for bituminous coal is calculated on a county basis, county values are summed, and then normalized with the State published value.[3] Sources of inputs and normalization are discussed below.

The first step in the methodology is to determine industrial bituminous coal consumption by county. This is accomplished by adjusting county area source employment figures for SIC categories 20 through 39 by a fuel intensity factor. For the purpose of this calculation, county area source employment is defined as the difference between total county employment and point source employment for each SIC category. The fuel intensity ratio is a measure of fuel use intensity per employee, which is determined by dividing the State consumption of fuel -- in this case bituminous coal -- for each SIC category by the respective State employment. (If State data are not available, regional data are used. If regional data are not available, national data are used.) County area source consumption is then summed for all counties to obtain State area source consumption for bituminous coal.

County consumption values are then normalized to agree with the State level calculated industrial area source consumption values for bituminous coal. Reported industrial area source consumption is calculated by subtracting the point source industrial bituminous coal consumption as reported to AIRS/FS from the published State total bituminous coal consumption.

Sources of information on county total and point source employment figures for SIC categories 20 through 39 are obtained from the Census Bureau's County Business Patterns.[22] Total industrial coal consumption for States for each year is found in DOE's State Energy Data Report[7] and industrial coal shipments for States for each year are found in DOE's Coal Distribution: January-December report.[10] Information concerning consumption of bituminous coal by SIC category is found in DOE's Manufacturing Energy Consumption Survey[23] and is used to calculate fuel intensity factors. State industrial point source data are taken directly from AIRS/FS Point Source Data Files.[20]

Bituminous Coal Equations --

A normalized estimate of County Industrial Bituminous Coal Consumption (NCB) (in short tons) is computed using the formula:

$$NCB = CIF_4 \cdot \frac{SIB}{\sum_{n=1}^{c} CIF_{4,n}}$$

where: NCB = Normalized county industrial bituminous coal consumption
CIF_4 = Estimated county bituminous consumption by industrial sources (computed below)
SIB = Reported State industrial area source bituminous coal consumption (computed below)
c = Number of counties in State

SIB is computed using the formula:

$$SIB = SOIB - SPB$$

If SIB < 0, then set SIB = 0.

where: SOIB = Total State industrial bituminous coal consumption (computed below)
SPB = State industrial point source bituminous coal consumption (computed below)

SOIB is computed using the formula:

$$SOIB = TSB \cdot \frac{SSIB}{SSIB + SSCB}$$

where: TSB = Published State total industrial bituminous coal consumption
SSIB = Published total of bituminous shipments to "other industrial" users by State
SSCB = Published total of bituminous shipments to coke plants by State

SPB is computed using the formula:

$$SPB = \sum_{n=1}^{SCC} IPBS_n$$

where: SCC = AIRS Facility points for SCCs
1-02-002-**
1-02-003-**
3-90-002-**
3-90-003-**

BPCS = Annual throughput at the commercial point sources in the AIRS/FS Point Source Data Files[20] summed by State

An estimate of County Industrial Bituminous Fuel consumption (CIF_4) is derived with the following formula:

$$CIF_4 = \sum_{j=1}^{SIC} CAE_j \cdot FIR_{4j}$$

where: CIF_4 = Estimated county industrial consumption of bituminous coal
SIC = SIC codes 20 through 39.
CAE_j = County area source employment for SIC_j
FIR_{4j} = Fuel intensity ratio -- a measure of fuel use intensity per employee for bituminous coal by SIC category j

CAE_j is computed using the formula:

$$CAE_j = TCE_j - CPE_j$$

where: TCE_j = Total employment in county for SIC category j
CPE_j = Point source employment in county for SIC category j

State fuel intensity factor (FIR_{4j}) is computed using the formula:

$$FIR_{4j} = \frac{F_{4j}}{E_j}$$

where: $F4_j$ = State consumption of bituminous coal by SIC category j
E_j = Total employment in State for SIC category j in year of most recent Census of Manufacturers

NOTE: If input data are not available to compute **State** fuel intensity ratios, then RFR_{4j} is substituted for FIR_{4j} in the formula used to compute estimates of **county** industrial bituminous fuel consumption CIF_4. In this case the formula used is:

$$CIF_{4j} = \sum_{j=1}^{SIC} CAE_j \cdot RFR_{4j}$$

where: RFR_{4j} = Regional fuel intensity ratio for bituminous coal by SIC category j (computed below)

RFR_{4j} is computed using the formula:

$$RFR_{4j} = \frac{RF_{4j}}{RE_j}$$

where: RF_{4j} = Regional consumption of bituminous coal by SIC category j
RE_j = Total employment in census region for SIC category j in year of most recent Census of Manufacturers

NOTE: If input data are not available to compute **regional** fuel intensity ratios, then NFR_{4j} is substituted for FIR_{4j} in the formula used to compute estimates of **county** industrial anthracite fuel consumption CIF_4. In this case the formula used is:

$$CIF_{4j} = \sum_{j=1}^{SIC} CAE_j \cdot NFR_{4j}$$

where: NFR_{4j} = National fuel intensity ratio for bituminous coal by SIC category j (computed below)

NFR_{4j} is computed using the formula:

$$NFR_{4j} = \frac{NF_{4j}}{NE_j}$$

where: NF_{4j} = National consumption of bituminous coal by SIC category j
NE_j = Total employment in nation for SIC category j in year of most recent Census of Manufacturers

Bituminous Coal Emission Factors --

Weighted emission factors are taken from AIRS/FS Point Source Data Files[20] for SCC 1-02-002-**.

In order to obtain weighted emission factors for this category, the amount of coal consumption must be first obtained from AIRS FS for SCC 1-02-002-**. (The double asterisk "**" indicates a series of SCCs belonging to the general group 1-02-002.) The following general equation is then used to compute weighted emissions factors:

$$EF_W = \frac{(EF_{SCC1} \cdot FC_{SCC1}) + (EF_{SCC2} \cdot FC_{SCC2}) + \ldots}{(FC_{SCC1} + FC_{SCC2} + \ldots)}$$

where: EF_W = Weighted emission factor for a given pollutant
EF_{SCC1} = AP-42 emission factor for the first SCC in the series
FC_{SCC1} = Fuel consumption from AIRS/FS for the first SCC in the series

The average sulfur content for shipments from each coal producing State to other industrial users is taken from Coal Production[9] and weighted for each production district. District averages are weighted by shipments data from each 'district to a destination,' as found in Coal Distribution.[10] The control efficiency for particulates is calculated by projecting the previous year's control efficiency.

Distillate Oil

The methodology for determining distillate oil consumption by industrial area sources consists of two steps. County industrial fuel consumption for distillate oil is calculated on a county basis, county values are summed, and then normalized with the State published value.[11] Sources of inputs and normalization are discussed below.

The first step in the methodology is to determine industrial distillate oil consumption by county. This is accomplished by adjusting county area source employment figures for SIC categories 20 through 39 by a fuel intensity factor. For the purpose of this calculation, county area source employment is defined as the difference between total county employment and point source employment for each SIC category. The fuel intensity ratio is a measure of fuel use intensity per employee, which is determined by dividing the State consumption of fuel -- in this case distillate oil -- for each SIC category by the respective State employment. (If State data are not available, regional data are used. If regional data are not available, national data are used.) County area source consumption is then summed for all counties to obtain State area source consumption for distillate oil.

County consumption values are then normalized to agree with the State-level calculated industrial-area source consumption values for distillate oil. Reported industrial-area source consumption is calculated by subtracting the point source industrial distillate oil consumption as reported to AIRS/FS from the adjusted State total distillate oil consumption. The adjusted State total of distillate oil consumption is obtained by subtracting the distillate oil consumed at petroleum refinery process heaters from the published State total distillate oil deliveries (adjusted sales).

Sources of information on county total and point source employment figures for SIC categories 20 through 39 are obtained from the Census Bureau's County Business Patterns.[22] Total industrial

distillate oil consumption for States for each year is found in DOE's Fuel Oil and Kerosene Sales[12] report. The Fuel Oil and Kerosene Sales publication does not report consumption. However, the AMS methodology assumes that delivery (adjusted sales) data equate to consumption. Information concerning the amount of distillate oil consumed at petroleum refineries is found in DOE's Petroleum Supply Annual.[24] Information concerning consumption of distillate oil by SIC category is found in DOE's Manufacturing Energy Consumption Survey[23] and is used to calculate fuel intensity factors. State industrial point source data are taken directly from AIRS/FS Point Source Data Files.[20]

Distillate Oil Equations --

A normalized estimate of County Industrial Distillate Oil Consumption (NCD) (1000 gallons) is computed using the formula:

$$NCD = CIF_2 \cdot \frac{SID}{\sum_{n=1}^{c} CIF_{2,n}}$$

where: NCD = Normalized county industrial distillate oil consumption
CIF_2 = Estimated county distillate oil consumption by industrial sources (computed below)
SID = Reported State industrial area source distillate oil consumption
c = Number of counties in State

SID is computed using the formula:

$$SID = TSD - SPD$$

If SID < 0, then set SID = 0.

where: TSD = Total State industrial distillate oil consumption (computed below)
SPD = State industrial point source distillate oil consumption (computed below)

SPD is computed using the formula:

$$SPD = \sum_{n=1}^{SCC} DPIS_n$$

where: SCC = AIRS Facility points for SCCs
1-02-005-**
3-90-005-**
2-02-001-**
2-02-004-**
2-02-009-**

DPIS = Annual throughput at industrial point sources in the AIRS/FS Point Source Data Files[20] summed by State

TSD is computed using the formula:

$$TSD = SOCD + SDI$$

where: SOCD = State distillate oil consumption at oil companies (computed below)
SDI = State distillate oil deliveries to industry (computed below)

SDI is computed using the equation:

SDI = State Industrial Distillate # 1 +
State Industrial Distillate # 2 +
State Industrial Diesel # 2 +
State Industrial Distillate # 4 +
State Industrial Kerosene +
State All Other Distillate +
State All Other Kerosene

SOCD is computed using the formula:

$$SOCD = SDO - SPHD$$

If SOCD < 0, then set SOCD = 0.

where: SDO = State distillate oil deliveries to oil companies
SPHD = State distillate oil used for process heating at oil companies (computed below)

SPHD is computed using the formula:

$$SPHD = DRO \cdot \frac{SDO}{\sum_{n=1}^{s} SDO_n}$$

where: DRO = Distillate oil consumed at refineries by Petroleum Administration for Defense (PAD) district
SDO = State distillate oil deliveries to oil companies
s = Number of States in a PAD district

An estimate of County Industrial Distillate Fuel consumption (CIF_2) is derived with the following formula:

$$CIF_2 = \sum_{j=1}^{SIC} CAE_j \cdot FIR_{2j}$$

where: CIF_2 = Estimated county industrial consumption of distillate oil
SIC = SIC codes 20 through 39.
CAE_j = County area source employment for SIC_j
FIR_{2j} = State fuel intensity ratio: a measure of fuel use intensity per employee for distillate oil by SIC category j

CAE_j is computed using the formula:

$$CAE_j = TCE_j - CPE_j$$

where: TCE_j = Total employment in county for SIC category j
CPE_j = Point source employment in county for SIC category j

State fuel intensity ratio (FIR_{2j}) is computed using the formula:

$$FIR_{2j} = \frac{F_{2j}}{E_j}$$

where: $F2_j$ = State consumption of distillate oil by SIC category j
E_j = Total employment in State for SIC category j in year of most recent Census of Manufacturers

NOTE: If input data are not available to compute **State** fuel intensity ratios, then RFR_{2j} is substituted for FIR_{2j} in the formula used to compute estimates of **county** industrial distillate oil fuel consumption CIF_2. In this case the formula used is:

$$CIF_{2j} = \sum_{j=1}^{SIC} CAE_j \cdot RFR_{2j}$$

where: RFR_{2j} = Regional fuel intensity ratio for distillate oil by SIC category j (computed below)

RFR_{2j} is computed using the formula:

$$RFR_{2j} = \frac{RF_{2j}}{RE_j}$$

where: RF_{2j} = Regional consumption of distillate oil by SIC category j
RE_j = Total employment in census region for SIC category j in year of most recent Census of Manufacturers

NOTE: If input data are not available to compute **regional** fuel intensity ratios, then NFR_{2j} is substituted for FIR_{2j} in the formula used to compute estimates of **county** industrial distillate oil fuel consumption CIF_2. In this case the formula used is:

$$CIF_{2j} = \sum_{j=1}^{SIC} CAE_j \cdot NFR_{2j}$$

where: NFR_{2j} = National fuel intensity ratio for distillate oil by SIC category j (computed below)

NFR_{2j} is computed using the formula:

$$NFR_{2j} = \frac{NF_{2j}}{NE_j}$$

where: NF_{2j} = National consumption of distillate oil by SIC category j
NE_j = Total employment in nation for SIC category j in year of most recent Census of Manufacturers

Distillate Oil Emission Factors --

Emission factors are found in AP-42, Table 1.3-1.[8] For SO_2, the average sulfur contents for No. 1, No. 2, and No. 4 fuel oils are taken from Heating Oils.[13]

Residual Oil

The methodology for determining residual oil consumption by industrial area sources consists of two steps. County industrial fuel consumption for residual oil is calculated on a county basis, county values are summed, and then the figures are normalized with the State published value.[11] Sources of inputs and normalization are discussed below.

The first step in the methodology is to determine industrial residual oil consumption by county. This is accomplished by adjusting county area source employment figures for SIC categories 20 through 39 by a fuel intensity factor. For the purpose of this calculation, county area source employment is defined as the difference between total county employment and point source employment for each SIC category. The fuel intensity ratio is a measure of fuel use intensity per employee, which is determined by dividing the State consumption of fuel -- in this case residual oil -- for each SIC category by the respective State employment. (If State data are not available, regional data are used. If regional data are not available, national data are used.) County area source consumption is then summed for all counties to obtain State area source consumption for residual oil.

County consumption values are then normalized to agree with the State level calculated industrial area source consumption values for residual oil. Reported industrial area source consumption is calculated by subtracting the point source industrial residual oil consumption as reported to AIRS/FS from the adjusted State total residual oil consumption. The adjusted State total residual oil consumption is obtained by subtracting the residual oil consumed at petroleum refinery process heaters from the published State total residual oil deliveries (adjusted sales).

Sources of information on county total and point source employment figures for SIC categories 20 through 39 are obtained from the Census Bureau's County Business Patterns.[22] Total industrial residual oil consumption for States for each year is found in DOE's Fuel Oil and Kerosene Sales.[12] The Fuel Oil and Kerosene Sales publication does not report consumption. However, the AMS methodology assumes that delivery (adjusted sales) data equate to consumption. Information concerning the amount of residual oil consumed at petroleum refineries is found in DOE's Petroleum Supply Annual.[24] Information concerning consumption of residual oil by SIC category is found in DOE's Manufacturing Energy Consumption Survey[23] and is used to calculate fuel intensity factors. State industrial point source data are taken directly from AIRS/FS Point Source Data Files.[20]

Residual Oil Equations --

A normalized estimate of County Industrial Residual Oil Consumption (NCR) (1000 gallons) is computed using the formula:

$$NCR = CIF_1 \cdot \frac{SIR}{\sum_{n=1}^{c} CIF_{1,n}}$$

where:
- NCR = Normalized county industrial residual oil consumption
- CIF_1 = Estimated county residual oil consumption by industrial sources (computed below)
- SIR = Reported State industrial area source residual oil consumption (computed below)
- c = Number of counties in State

SIR is computed using the equation:

$$SIR = TSR - SPR$$

If SIR < 0, then set SIR = 0.

where: TSR = Total State industrial residual oil consumption (computed below)
SPR = State industrial point source residual oil consumption (computed below)

SPR is computed using the formula:

$$SPR = \sum_{n=1}^{SCC} RPIS_n$$

where: SCC = AIRS Facility points for SCCs
1-02-004-**
3-90-004-**
2-02-005-**
RPIS = Annual throughput at industrial point sources in the AIRS/FS Point Source Data Files[20] summed by State

TSR is computed using the equation:

$$TSR = SOCR + SRI$$

where: SOCR = State residual oil consumption at oil companies (computed below)
SRI = State residual oil deliveries to industry (computed below)

SRI is computed using the equation:

SRI = State Industrial Residual Oil +
State All Other Residual Oil

SOCR is computed using the equation:

$$SOCR = SRO + SPHR$$

If SOCR < 0, then set SOCR = 0.

where: SRO = State residual oil deliveries to oil companies
SPHR = State residual oil used for process heating at oil companies (computed below)

SPRH is computed using the equation:

$$SPHR = RRO \cdot \frac{SRO}{\sum_{n=1}^{s} SRO_n}$$

where: RRO = Residual oil consumed at refineries by PAD district
SRO = State residual oil deliveries to oil companies
s = Number of States in a PAD district

An estimate of County Industrial Residual Fuel Oil consumption (CIF_1) is derived with the following formula:

$$CIF_1 = \sum_{j=1}^{SIC} CAE_j \cdot FIR_{1j}$$

where: CIF_1 = Estimated county industrial consumption of residual oil
SIC = SIC codes 20 through 39
CAE_j = County area source employment for SIC_j
FIR_{1j} = State fuel intensity ratio: a measure of fuel use intensity per employee for residual oil by SIC category j

CAE_j is computed using the formula:

$$CAE_j = TCE_j - CPE_j$$

where: TCE_j = Total employment in county for SIC category j
CPE_j = Point source employment in county for SIC category j

State fuel intensity ratio (FIR_{1j}) is computed using the formula:

$$FIR_{1j} = \frac{F_{1j}}{E_j}$$

where: F_{1j} = State consumption of residual oil by SIC category j
E_j = Total employment in State for SIC category j in year of most recent Census of Manufacturers

NOTE: If input data are not available to compute **State** fuel intensity ratios, then RFR_{1j} is substituted for FIR_{1j} in the formula used to compute estimates of county industrial residual oil fuel consumption CIF_1. In this case the formula used is:

$$CIF_{1J} = \sum_{J=1}^{SIC} CAE_J \cdot RFR_{1J}$$

where: RFR_{1j} = Regional fuel intensity ratio for residual oil by SIC category j (computed below)

RFR_{1j} is computed using the formula:

$$RFR_{1J} = \frac{RF_{1J}}{RE_J}$$

where: RF_{1j} = Regional consumption of residual oil by SIC category j
RE_j = Total employment in census region for SIC category j in year of most recent Census of Manufacturers

NOTE: If input data are not available to compute **regional** fuel intensity ratios, then NFR_{1j} is substituted for FIR_{1j} in the formula used to compute estimates of **county** industrial residual oil fuel consumption CIF_1. In this case the formula used is:

$$CIF_{1J} = \sum_{J=1}^{SIC} CAE_J \cdot NFR_{1J}$$

where: NFR_{1j} = National fuel intensity ratio for residual oil by SIC category j (computed below)

NFR_{1j} is computed using the formula:

$$NFR_{1J} = \frac{NF_{1J}}{NE_J}$$

where: NF_{1j} = National consumption of residual oil by SIC category j
NE_j = Total employment in nation for SIC category j in year of most recent Census of Manufacturers

Residual Oil Emission Factors --

Emission factors are found in AP-42, Table 1.3-1.[8] For SO_2, the average sulfur content for No. 6 fuel oil is obtained from Heating Oils.[13]

Natural Gas

Originally, the method used for determining natural gas consumption by industrial area sources combined natural gas use at boilers and natural gas use at IC engines. However, the AMS methodology has been modified so that these two uses of natural gas are considered separately. In addition, LPG was also included in the natural gas estimate. The AMS methodology will estimate LPG consumption as a separate entity. The following sections describe the steps used to estimate natural gas consumption for boilers and IC engines.

Natural Gas Consumed at Boilers --

The methodology for determining natural gas consumption by industrial area sources at boilers consists of two steps. County industrial fuel consumption for natural gas is calculated on a county basis, county values are summed, and then normalized with the State published value.[3] Sources of inputs and normalization are discussed below.

The first step in the methodology is to determine industrial natural gas consumption by county. This is accomplished by adjusting county area source employment figures for SIC categories 20 through 39 by a fuel intensity factor. For the purpose of this calculation, county area source employment is defined as the difference between total county employment and point source employment for each SIC category. The fuel intensity ratio is a measure of fuel use intensity per employee, which is determined by dividing the State consumption of fuel -- in this case natural gas -- for each SIC category by the respective State employment. (If State data are not available, regional data are used. If regional data are not available, national data are used.) County area source consumption is then summed for all counties to obtain State area source consumption for natural gas.

County consumption values are then normalized to agree with the State-level calculated industrial area source consumption values for natural gas. Reported industrial area source consumption is calculated by subtracting the point source industrial natural gas consumption as reported to AIRS/FS from the adjusted State total natural gas consumption. The adjusted State total natural gas consumption is obtained by subtracting the natural gas used for chemical feedstock purposes from the published State total industrial natural gas consumption. The AMS methodology considers four chemicals to be the most important for chemical feedstock purposes. These are: acetylene, ammonia, carbon black, and methanol.

Sources of information on county total and point source employment figures for SIC categories 20 through 39 are obtained from the Census Bureau's County Business Patterns.[22] Total industrial natural gas consumption for States for each year is found in DOE's Natural Gas Annual.[17] Information concerning the use of natural gas as a chemical feedstock is found in the Directory of Chemical Producers[25] and information concerning the amounts of the four chemicals produced in a given year is found in the Chemical & Engineering News[26] and Synthetic Organic Chemicals.[27] Information concerning consumption of natural gas by SIC category is found in DOE's Manufacturing Energy Consumption Survey[23] and is used to calculate fuel intensity factors. State industrial point source data are taken directly from AIRS/FS Point Source Data Files.[20]

Natural Gas Equations (Boilers) --

A normalized estimate of County Industrial Natural Gas Consumption in Boilers (NCGB) (million cubic feet) is computed using the formula:

$$NCGB = CIF_3 \cdot \frac{SIGB}{\sum_{n=1}^{c} CIF_{3,n}}$$

where: NCGB = Normalized county industrial natural gas consumption in boilers
CIF_3 = Estimated county natural gas consumption by industrial sources (computed below)
SIGB = Reported State industrial area source natural gas consumption in boilers (computed below)
c = Number of counties in State

SIGB is computed using the formula:

$$SIGB = TSGB - SPGB$$

If SIGB < 0, then set SIGB = 0.

where: TSGB = Total State industrial natural gas consumption in boilers (computed below)
SPGB = State industrial point source natural gas consumption in boilers (computed below)

The equation to compute SPGB is as follows:

$$SPGB = \sum_{n=1}^{SCC} GBPIS_n$$

where: SCC = AIRS Facility points for SCCs
1-02-006-**
3-90-006-**
GBPIS = Annual throughput at industrial point sources in the AIRS/FS Point Source Data Files[20] summed by State

TSGB is computed using the equation:

$$TSGB = TSPG - TSFG$$

where: TSPG = Published State total industrial natural gas

TSFG = Total State natural gas used for feedstock purposes (computed below)

TSFG is computed using the equation:

$$TSFG = \sum_{n=1}^{ch} \left(\frac{TAC_n \cdot TCP_n \cdot PNG_n}{1{,}000{,}000} \right) \cdot PCC_n$$

where:
- ch = 1 for Acetylene; 2 for Ammonia; 3 for Carbon Black; 4 for Methanol
- TAC = Typical amounts of natural gas required to produce a given chemical (cubic feet)
- TCP = Amount of chemical produced in current year (short tons)
- PNG = Percent (%) production capacity using natural gas process
- PCC = Percent (%) production capacity for a State by chemical

An estimate of County Industrial Natural Gas Fuel consumption (CIF_3) is derived with the following formula:

$$CIF_3 = \sum_{j=1}^{SIC} CAE_j \cdot FIR_{3j}$$

where:
- CIF_3 = Estimated county industrial consumption of natural gas
- SIC = SICs 20 through 39
- CAE_j = County area source employment for SIC_j
- FIR_{3j} = State intensity ratio: a measure of fuel use intensity per employee for natural gas by SIC category j

CAE_j is computed using the formula:

$$CAE_j = TCE_j - CPE_j$$

where:
- TCE_j = Total employment in county for SIC category j
- CPE_j = Point source employment in county for SIC category j

State fuel intensity factor (FIR_{3j}) is computed using the formula:

$$FIR_{3j} = \frac{F_{3j}}{E_j}$$

where: F_{3j} = State consumption of natural gas by SIC category j
E_j = Total employment in State for SIC category j in year of most recent Census of Manufacturers

NOTE: If input data are not available to compute **State** fuel intensity ratios, then RFR_{3j} is substituted for FIR_{3j} in the formula used to compute estimates of **county** industrial natural gas fuel consumption CIF_3. In this case the formula used is:

$$CIF_{3j} = \sum_{j=1}^{SIC} CAE_j \cdot RFR_{3j}$$

where: RFR_{3j} = Regional fuel intensity ratio for natural gas by SIC category j (computed below)

RFR_{3j} is computed using the formula:

$$RFR_{3j} = \frac{RF_{3j}}{RE_j}$$

where: RF_{3j} = Regional consumption of natural gas by SIC category j
RE_j = Total employment in census region for SIC category j in year of most recent Census of Manufacturers

NOTE: If input data are not available to compute **regional** fuel intensity ratios, then NFR_{3j} is substituted for FIR_{3j} in the formula used to compute estimates of **county** industrial natural gas fuel consumption CIF_3. In this case the formula used is:

$$CIF_{3j} = \sum_{j=1}^{SIC} CAE_j \cdot NFR_{3j}$$

where: NFR_{3j} = National fuel intensity ratio for natural gas by SIC category j (computed below)

NFR_{3j} is computed using the formula:

$$NFR_{3j} = \frac{NF_{3j}}{NE_j}$$

where: NF_{3j} = National consumption of natural gas by SIC category j
NE_j = Total employment in nation for SIC category j in year of most recent Census of Manufacturers

Natural Gas Emission Factors (Boilers) –

Boiler emission factors are obtained from AP-42, Table 1.4-1[8] for natural-gas-fired industrial boilers of the 10 to 100 million Btu range.

Natural Gas Consumed at IC Engines –

The methodology for determining natural gas consumption by industrial area sources IC engines consists of two steps. County industrial fuel consumption for natural gas is calculated on a county basis, county values are summed, and then the figures are normalized with the State published value.[3] Sources of inputs and normalization are discussed below.

The first step in the methodology is to determine industrial natural gas consumption by county. This is accomplished by adjusting county area source employment figures for SIC categories 20 through 39 by a fuel intensity factor. For the purpose of this calculation, county area source employment is defined as the difference between total county employment and point source employment for each SIC category. The fuel intensity ratio is a measure of fuel use intensity per employee, which is determined by dividing the State consumption of fuel -- in this case natural gas -- for each SIC category by the respective State employment. If State data are not available, regional data are used. If regional data are not available, national data are used. County area source consumption is then summed for all counties to obtain State area source consumption for natural gas.

County consumption values are then normalized to agree with the State-level calculated industrial area source consumption values for natural gas. Reported industrial area source consumption is calculated by subtracting the point source industrial natural gas consumption as reported to AIRS/FS from the published State total natural gas consumption for two categories: pipeline fuel, and lease and plant fuel.

Sources of information on county total and point source employment figures for SIC categories 20 through 39 are obtained from the Census Bureau's County Business Patterns.[22] Total industrial natural gas consumption for States for each year is found in DOE's Natural Gas Annual.[17] Information concerning consumption of natural gas by SIC category is found in DOE's Manufacturing Energy Consumption Survey[23] and is used to calculate fuel intensity factors. State industrial point source data are taken directly from AIRS/FS Point Source Data Files.[20]

Natural Gas Equations (IC Engines) –

A normalized estimate of County Industrial Natural Gas Consumption in IC Engines (NCGE) (million cubic feet) is computed using the formula:

$$NCGE = CIF_3 \cdot \frac{SIGE}{\sum_{n=1}^{c} CIF_{3,n}}$$

where: NCGE = Normalized county industrial natural gas consumption in IC engines

CIF_3 = Estimated county natural gas consumption by industrial sources (computed below)

SIGE = Reported State industrial area source natural gas consumption in IC engines (computed below)

c = Number of counties in State

SIGE is computed using the formula:

$$SIGE = TSLP + TSPF - SPGE$$

If SIGE < 0, then set SIGE = 0.

where: TSLP = Published State total lease and plant fuel natural gas consumption

TSPF = Published State total pipeline fuel natural gas consumption

SPGE = Reported State industrial point source natural gas consumption for IC engines (computed below)

SPGE is computed using the formula:

$$SPGE = \sum_{n=1}^{SCC} GEPIS_n$$

where: SCC = AIRS Facility points for SCC 2-02-002-**

GEPIS = Annual throughput at industrial point sources in the AIRS/FS Point Source Data Files[20] summed by State

An estimate of County Industrial Natural Gas Fuel consumption (CIF_3) is derived with the following formula:

$$CIF_3 = \sum_{j=1}^{SIC} CAE_j \cdot FIR_{3j}$$

where: CIF_3 = Estimated county industrial consumption of natural gas

SIC = SIC codes 20 through 39

CAE_j = County area source employment for SIC_j

FIR_{3j} = State fuel intensity ratio: a measure of fuel use intensity per employee for natural gas by SIC category j

CAEj is computed using the formula:

$$CAE_j = TCE_j - CPE_j$$

where: TCE_j = Total employment in county for SIC category j
CPE_j = Point source employment in county for SIC category j

State fuel intensity factor (FIR_{3j}) is computed using the formula:

$$FIR_{3j} = \frac{F_{3j}}{E_j}$$

where: F_{3j} = State consumption of natural gas by SIC category j
E_j = Total employment in State for SIC category j in year of most recent Census of Manufacturers

NOTE: If input data are not available to compute **State** fuel intensity ratios, then RFR_{3j} is substituted for FIR_{3j} in the formula used to compute estimates of **county** industrial natural gas fuel consumption CIF_3. In this case the formula used is:

$$CIF_{3j} = \sum_{j=1}^{SIC} CAE_j \cdot RFR_{3j}$$

where: RFR_{3j} = Regional fuel intensity ratio for natural gas by SIC category j (computed below)

RFR_{3j} is computed using the formula:

$$RFR_{3j} = \frac{RF_{3j}}{RE_j}$$

where: RF_{3j} = Regional consumption of natural gas by SIC category j
RE_j = Total employment in census region for SIC category j in year of most recent Census of Manufacturers

NOTE: If input data are not available to compute **regional** fuel intensity ratios, then NFR_{3j} is substituted for FIR_{3j} in the formula used to compute estimates of **county** industrial natural gas fuel consumption CIF_3. In this case the formula used is:

$$CIF_{3j} = \sum_{j=1}^{SIC} CAE_j \cdot NFR_{3j}$$

where: NFR_{3j} = National fuel intensity ratio for natural gas by SIC category j (computed below)

NFR_{3j} is computed using the formula:

$$NFR_{3j} = \frac{NF_{3j}}{NE_j}$$

where: NF_{3j} = National consumption of natural gas by SIC category j
NE_j = Total employment in nation for SIC category j in year of most recent Census of Manufacturers

Natural Gas Emission Factors (IC Engines) --

For gas pipelines and plants, emission factors are obtained for SCC 2-02-002-01 (Turbines) and SCC 2-02-002-02 (IC Engines) from AIRS/FS Point Source Data Files.[20] Emission factors are weighted according to the total AIRS/FS fuel consumed by each type.

In order to obtain weighted emission factors for this category, the amount of natural gas consumption must be first obtained from AIRS/FS for SCC 2-02-002-01 and 2-02-002-02. The following general equation is then used to compute weighted emission factors:

$$EF_W = \frac{(EF_{SCC1} \cdot FC_{SCC1}) + (EF_{SCC2} \cdot FC_{SCC2}) + \ldots}{(FC_{SCC1} + FC_{SCC2} + \ldots)}$$

where: EF_W = Weighted Emission factor for a given pollutant
EF_{SCC1} = AP-42 emission factor for the first SCC in the series
FC_{SCC1} = Fuel consumption from AIRS/FS for the first SCC in the series

LPG

Originally, the method used for determining natural gas consumption by industrial area sources combined natural gas and LPG. However, the AMS methodology has been modified so that these two types of fuels are considered separately.

The methodology for determining LPG consumption by industrial area sources consists of two steps. County industrial fuel consumption for LPG is calculated on a county basis, county values are summed, and then normalized with the State published value.[3] Sources of inputs and normalization are discussed below.

The first step in the methodology is to determine industrial LPG consumption by county. This is accomplished by adjusting county area source employment figures for SIC categories 20 through 39 by a fuel intensity factor. For the purpose of this calculation, county area source employment is defined as the difference between total county employment and point source employment for each SIC category. The fuel intensity ratio is a measure of fuel use intensity per employee, which is determined by dividing the State consumption of fuel -- in this case LPG -- for each SIC category by the respective State employment. (If State data are not available, regional data are used. If regional data are not available, national data are used.) County area source consumption is then summed for all counties to obtain State area source consumption for LPG.

County consumption values are then normalized to agree with the State-level calculated industrial area source consumption values for LPG. Reported industrial area source consumption is calculated by subtracting the point source industrial LPG consumption as reported to AIRS/FS[20] from the published State total LPG consumption.

Sources of information on county total and point source employment figures for SIC categories 20 through 39 are obtained from the Census Bureau's County Business Patterns.[22] Total industrial LPG consumption for States for each year is found in DOE's State Energy Data Report.[7] Information concerning consumption of LPG by SIC category is found in DOE's Manufacturing Energy Consumption Survey[23] and is used to calculate fuel intensity factors. State industrial point source data are taken directly from AIRS/FS Point Source Data Files.[20]

LPG Equations --

A normalized estimate of County Industrial LPG Consumption (NCLP) (in 1000 gallons) is computed using the formula:

$$NCLP = CIF_5 \cdot \frac{SILP}{\sum_{n=1}^{c} CIF_{5,n}}$$

where:

NCLP	=	Normalized county industrial LPG consumption
CIF_5	=	Estimated county LPG consumption by industrial sources (computed below)
SILP	=	Reported State industrial area source LPG consumption (computed below)
c	=	Number of counties in State

SILP is computed using the formula:

$$SILP = TSLP + TSPF - SPGE$$

If SILP < 0, then set SILP = 0.

where: TSLP = Published State total lease and plant fuel LPG consumption
TSPF = Published State total pipeline fuel LPG consumption
SPGE = Reported State industrial point source natural gas consumption for IC engines (computed below)

SPGE is computed as follows:

$$SPGE = \sum_{n=1}^{SCC} LPPIS_n$$

where: SCC = AIRS Facility points for SCCs
1-02-010-**
2-02-010-**
3-90-010-**
LPPIS = Annual throughput at industrial point sources in the AIRS/FS Point Source Data Files[20] summed by State

An estimate of County Industrial LPG Fuel consumption (CIF_5) is derived with the following formula:

$$CIF_5 = \sum_{j=1}^{SIC} CAE_j \cdot FIR_{5j}$$

where: CIF_5 = Estimated county industrial consumption of LPG
SIC = SIC codes 20 through 39
CAE_j = County area source employment for SIC_j
FIR_{5j} = State fuel intensity ratio: a measure of fuel use intensity per employee for LPG by SIC category j

CAE_j is computed using the formula:

$$CAE_j = TCE_j - CPE_j$$

where: TCE_j = Total employment in county for SIC category j
CPE_j = Point source employment in county for SIC category j

State fuel intensity ratio (FIR_{5j}) is computed using the formula:

$$FIR_{5j} = \frac{F_{5j}}{E_j}$$

where: F_{5j} = State consumption of LPG by SIC category j
E_j = Total employment in State for SIC category j in year of most recent Census of Manufacturers

NOTE: If input data are not available to compute **State** fuel intensity ratios, then RFR_{5j} is substituted for FIR_{5j} in the formula used to compute estimates of **county** industrial LPG fuel consumption CIF_5. In this case the formula used is:

$$CIF_5 = \sum_{J=1}^{SIC} CAE_J \cdot RFR_{5J}$$

where: RFR_{5j} = Regional fuel intensity ratio for LPG by SIC category j (computed below)

RFR_{5j} is computed using the formula:

$$RFR_{5J} = \frac{RF_{5J}}{RE_J}$$

where: RF_{5j} = Regional consumption of LPG by SIC category j
RE_j = Total employment in census region for SIC category j in year of most recent Census of Manufacturers

NOTE: If input data are not available to compute **regional** fuel intensity ratios, then NFR_{5j} is substituted for FIR_{5j} in the formula used to compute estimates of **county** industrial LPG fuel consumption CIF_5. In this case the formula used is:

$$CIF_5 = \sum_{J=1}^{SIC} CAE_J \cdot NFR_{5J}$$

where: NFR_{5j} = National fuel intensity ratio for LPG by SIC category j (computed below)

NFR_{5j} is computed using the formula:

$$NFR_{5J} = \frac{NF_{5J}}{NE_J}$$

where: NF_{5j} = National consumption of LPG by SIC category j
NE_j = Total employment in nation for SIC category j in year of most recent Census of Manufacturers

LPG Emission Factors --

Emission factors are found in AP-42, Table 1.5-1.[8]

Wood

A method to estimate area source emissions from industrial wood combustion sources may be developed in the future.

Industrial Coke

A method to estimate area source emissions from industrial wood combustion sources may be developed in the future.

Process Gas

A method to estimate area source emissions from industrial wood combustion sources may be developed in the future.

SULFUR CONTENT

Anthracite Coal

Sulfur content of anthracite coal for each county is not computed. A national value is input and used without any manipulation.[3] For the purpose of this calculation the sulfur content of anthracite coal is assumed to be 0.7 percent.[9]

$$AS = NIV$$

where: AS = County anthracite coal sulfur content for all consumer categories
NIV = National input value for sulfur content of anthracite coal

Bituminous Coal

Residential/Commercial --

The original methodology called for estimating a weighted average sulfur content for all source categories, namely, residential coal combustion, commercial/institutional coal combustion, and industrial coal combustion[3]. However, the AMS methodology has been modified to estimate weighted average sulfur contents for residential and commercial/institutional separately from the industrial sector. The average sulfur content for the appropriate sector is taken from Coal Production.[9] District averages are then weighted by coal shipment data from the Coal Distribution: January-December[10] report. Weight of sulfur from commercial point sources is obtained from AIRS/FS[20].

A weighted average sulfur content of bituminous coal consumed at residential and commercial sources is calculated as follows:

$$CWRCS = SSRC$$

NOTE: If SSRC > 7 percent, then set SSRC = 3 percent

where: CWRCS = County weighted sulfur content of bituminous coal consumed at residential and commercial sources [% sulfur (S)]

SSRC = State weighted sulfur content of bituminous coal consumed at residential and commercial sources (computed below)

SSRC is computed using the formula:

$$SSRC = \frac{\left(\sum_{d=1}^{p} RCS_d \cdot SRB_d\right) - BPS}{\left(\sum_{d=1}^{p} SRB_d\right) - BPC}$$

where: RCS = Average sulfur content (% S) of bituminous coal shipped from production district/district grouping p for use by residential and commercial sources (computed below)

SRB = Bituminous shipments to State from production district/district grouping p for residential and commercial use

BPS = Weight of sulfur in bituminous coal consumed in State by commercial point sources (computed below)

BPC = Bituminous coal consumed in the State by commercial point sources (computed below)

NOTE:

$$If\ BPC > \sum_{d=1}^{p} SRB_d$$

OR

$$If\ BPS > \sum_{d=1}^{p} RCS_d \cdot SRB_d$$

then use the following equation:

$$SSRC = \frac{\sum_{d=1}^{p} RCS_d \cdot SRB_d}{\sum_{d=1}^{p} SRB_d}$$

RCS is computed as follows:

$$RCS_d = \frac{\sum_{d=1}^{p} SRB_d \cdot RCSC_d}{\sum_{d=1}^{p} SRB_d}$$

where: p = 1 for production district # 1
= 2 for production district # 2
= 3 for production district # 3 and 6
= 4 for production district # 4
= 5 for production district # 7
= 6 for production district # 8
= 7 for production district # 9
= 8 for production district # 10
= 9 for production district # 11
= 10 for production district # 12
= 11 for production district # 13
= 12 for production district # 14
= 13 for production district # 15
= 14 for production district # 16 and 17
= 15 for production district # 18
= 16 for production district # 19
= 17 for production district # 20
= 18 for production district # 21
= 19 for production district # 22 and 23

RCSC = Sulfur content (% S) of bituminous coal shipped from production district/district grouping p for use by residential and commercial sources

BPS is computed using the formula:

$$BPS = \sum_{n=1}^{SCC} FSCC_n \cdot BPCS_n$$

where: SCC = AIRS Facility points for SCCs 1-03-002-** and 1-03-003-**
FSCC = Sulfur content of bituminous coal at commercial point sources in the AIRS/FS Point Source Data Files[20] summed by State
BPCS = Annual throughput at commercial point sources in the AIRS/FS Point Source Data Files[20] summed by State

BPC is computed using the formula:

$$BPC = \sum_{n=1}^{SCC} BPCS_n$$

where: SCC = AIRS Facility points for SCCs 1-03-002-** and 1-03-003-**
BPCS = Annual throughput at commercial point sources in the AIRS/FS Point Source Data Files[20] summed by State

Industrial --

The original methodology called for estimating a weighted average sulfur content for all source categories, namely, residential coal combustion, commercial/institutional coal combustion, and industrial coal combustion[3]. However, the AMS methodology has been modified to estimate weighted average sulfur contents for residential and commercial/institutional separately from the industrial sector. The average sulfur content for the appropriate sector is taken from Coal Production.[9] District averages are then weighted by coal shipment data from the Coal Distribution: January-December[10] report. The weight of sulfur from commercial point sources is obtained from AIRS/FS[20].

A weighted average sulfur content of bituminous coal consumed at industrial sources is calculated as follows:

$$CWIS = SSI$$

NOTE: If SSI > 7 percent, then set SSI = 3 percent

where: CWIS = County weighted sulfur content of bituminous coal consumed at industrial sources (% S)
SSI = State weighted sulfur content of bituminous coal consumed at industrial sources (computed below)

SSI is computed using the formula:

$$SSI = \frac{\left(\sum_{d=1}^{p} IS_d \cdot SIB_d\right) - IPS}{\left(\sum_{d=1}^{p} SIB_d\right) - IPB}$$

where: IS = Average sulfur content (% S) of bituminous coal shipped from production district/district grouping p for use by industrial sources (computed below)

SIB = Bituminous shipments to State from production district/district grouping p for industrial use

IPS = Weight of sulfur in bituminous coal consumed in State by industrial point sources (computed below)

IPB = Bituminous coal consumed in the State by industrial point sources (computed below)

NOTE:

$$If\ IPB > \sum_{d=1}^{p} SIB_d$$

OR

$$If\ IPS > \sum_{d=1}^{p} IS_d \cdot SIB_d$$

then use the following equation:

$$SSI = \frac{\sum_{d=1}^{p} IS_d \cdot SIB_d}{\sum_{d=1}^{p} SIB_d}$$

IS_d is computed using the formula:

$$IS = \frac{\sum_{d=1}^{p} SIB_d \cdot ISC_d}{\sum_{d=1}^{p} SIB_d}$$

where: p = 1 for production district # 1
= 2 for production district # 2
= 3 for production district # 3 and 6
= 4 for production district # 4
= 5 for production district # 7
= 6 for production district # 8
= 7 for production district # 9
= 8 for production district # 10
= 9 for production district # 11
= 10 for production district # 12
= 11 for production district # 13
= 12 for production district # 14
= 13 for production district # 15
= 14 for production district # 16 and 17
= 15 for production district # 18
= 16 for production district # 19
= 17 for production district # 20
= 18 for production district # 21
= 19 for production district # 22 and 23

ISC = Sulfur content (% S) of bituminous coal shipped from production district/district grouping p for use by industrial sources

IPS is computed using the formula:

$$IPS = \sum_{n=1}^{SCC} FSCI_n \cdot IPBS_n$$

where: SCC = AIRS Facility points for SCCs
1-02-002-**
1-02-003-**
3-90-002-**
3-90-003-**

FSCI = Sulfur content of bituminous coal at industrial point sources in the AIRS/FS Point Source Data Files[20] summed by State

IPBS = Annual throughput of bituminous coal at industrial point sources in the AIRS/FS Point Source Data Files[20] summed by State

IPB is computed using the formula:

$$IPB = \sum_{n=1}^{SCC} IPBS_n$$

where: SCC = AIRS Facility points for SCCs
1-02-002-**
1-02-003-**
3-90-002-**
3-90-003-**

IPBS = Annual throughput at industrial point sources in the AIRS/FS Point Source Data Files[20] summed by State

Distillate Oil

Sulfur content of distillate oil is a county statistical value. This value is not computed or manipulated at the present time. Average sulfur contents for No. 1, No. 2, and No. 4 fuel oils are taken from Heating Oils.[13]

$$CDS = SDS$$

where: CDS = County distillate oil for all fuel categories
SDS = State input value for sulfur content of distillate oil

Residual Oil

Sulfur content of residual oil is a county statistical value. This value is not computed or manipulated at the present time. Average sulfur content for No. 6 fuel oil is taken from Heating Oils[13].

$$CRS = SRS$$

where: CRS = County residual oil for all fuel categories
SRS = State input value for sulfur content of residual oil

ASH CONTENT

Anthracite Coal

Ash content of anthracite coal for each county is not computed. A national value is input and used without any manipulation.[9] For the purpose of this calculation ash content is assumed to be 11.0 percent.

$$AA = NIV$$

where: AA = County anthracite coal ash content for all consumer categories

NIV = National input value for ash content of anthracite coal

Bituminous Coal

Residential/Commercial –

The original methodology called from estimating a weighted average ash content for all source categories, namely, residential coal combustion, commercial/institutional coal combustion, and industrial coal combustion[3]. However, the AMS methodology has been modified to estimate weighted average ash contents for residential and commercial/institutional separately from the industrial sector. The average ash content for the appropriate sector is taken from Coal Production.[9] District averages are then weighted by coal shipment data from the Coal Distribution: January-December[10] report. Weight of ash from commercial point sources is obtained from AIRS/FS[20].

A weighted average ash content of bituminous coal consumed at residential and commercial sources is calculated as follows:

$$CWRCA = ASRC$$

NOTE: If ASRC > 25 percent, then set ASRC = 15 percent

where: CWRCA = County weighted ash content of bituminous coal consumed at residential and commercial sources [% ash (A)]

ASRC = State weighted ash content of bituminous coal consumed at residential and commercial sources (computed below)

ASRC is computed using the formula:

$$ASRC = \frac{\left(\sum_{d=1}^{p} RCA_d \cdot SRB_d\right) - BPA}{\left(\sum_{d=1}^{p} SRB_d\right) - BPC}$$

where: RCA = Average ash content (% A) of bituminous coal shipped from production district/district grouping p for use by residential and commercial sources (computed below)

SRB = Bituminous shipments to State from production district/district grouping p for residential and commercial use

BPA = Weight of ash in bituminous coal consumed in State by commercial point sources (computed below)

BPC = Bituminous coal consumed in the State by commercial point sources (computed below)

NOTE:

$$\text{If } BPC > \sum_{d=1}^{p} SRB_d$$

OR

$$\text{If } BPA > \sum_{d=1}^{p} RCA_d \cdot SRB_d$$

then use the equation:

$$ASRC = \frac{\sum_{d=1}^{p} RCA_d \cdot SRB_d}{\sum_{d=1}^{p} SRB_d}$$

RCA is computed as follows:

$$RCA = \frac{\sum_{d=1}^{p} SRB_d \cdot RCAC_d}{\sum_{d=1}^{p} SRB_d}$$

where: p = 1 for production district # 1
= 2 for production district # 2
= 3 for production district # 3 and 6
= 4 for production district # 4
= 5 for production district # 7
= 6 for production district # 8
= 7 for production district # 9
= 8 for production district # 10
= 9 for production district # 11
= 10 for production district # 12
= 11 for production district # 13
= 12 for production district # 14
= 13 for production district # 15

	=	14 for production district # 16 and 17
	=	15 for production district # 18
	=	16 for production district # 19
	=	17 for production district # 20
	=	18 for production district # 21
	=	19 for production district # 22 and 23
RCAC	=	Ash content (% A) of bituminous coal shipped from production district/district grouping p for use by residential and commercial sources

BPA is computed using the formula:

$$BPA = \sum_{n=1}^{SCC} FACC_n \cdot BPCS_n$$

where:	SCC	=	AIRS Facility points for SCCs 1-03-002-** 1-03-003-**
	FACC	=	Ash content of bituminous coal at commercial point sources in the AIRS/FS Point Source Data Files[20] summed by State
	BPCS	=	Annual throughput at commercial point sources in the AIRS/FS Point Source Data Files[20] summed by State

BPC is computed using the formula:

$$BPC = \sum_{n=1}^{SCC} BPCS_n$$

where:	SCC	=	AIRS Facility points for SCCs 1-03-002-** and 1-03-003-**
	BPCS	=	Annual throughput at commercial point sources in the AIRS/FS Point Source Data Files[20] summed by State

Industrial --

The original methodology called for estimating a weighted average ash content for all source categories, namely, residential coal combustion, commercial/institutional coal combustion, and industrial coal combustion[3]. However, the AMS methodology has been modified to estimate weighted average ash contents for residential and commercial/institutional separately from the industrial sector. The average ash content for the appropriate sector is taken from Coal Production.[9] District averages are then weighted by coal shipment data from the Coal Distribution: January-December[10] report. Weight of ash from industrial point sources is obtained from AIRS/FS[20].

A weighted average ash content of bituminous coal consumed at industrial sources is calculated as follows:

$$CWIA = ASI$$

NOTE: If ASI > 25 percent, then set ASI = 15 percent.

where: CWIA = County weighted ash content of bituminous coal consumed at industrial sources (% A)

ASI = State weighted ash content of bituminous coal consumed at industrial sources (computed below)

ASI is computed using the formula:

$$ASI = \frac{\left(\sum_{d=1}^{p} IA_d \cdot SIB_d\right) - IPA}{\left(\sum_{d=1}^{p} SIB_d\right) - IPB}$$

where: IA = Average ash content (% A) of bituminous coal shipped from production district/district grouping for use by industrial sources (computed below)

SIB = Bituminous shipments to State from production district/district grouping p for industrial use

IPA = Weight of ash in bituminous coal consumed in State by industrial point sources

IPB = Bituminous coal consumed in the State by industrial point sources

NOTE:

$$If\ IPB > \sum_{d=1}^{p} SIB_d$$

OR

$$If\ IPA > \sum_{d=1}^{p} IA_d \cdot SIB_d$$

then use the equation:

$$ASI = \frac{\sum_{d=1}^{p} IA_d \cdot SIB_d}{\sum_{d=1}^{p} SIB_d}$$

IA is computed using the formula:

$$IA = \frac{\sum_{d=1}^{p} SIB_d \cdot IAC_d}{\sum_{d=1}^{p} SIB_d}$$

where: p = 1 for production district # 1
= 2 for production district # 2
= 3 for production district # 3 and 6
= 4 for production district # 4
= 5 for production district # 7
= 6 for production district # 8
= 7 for production district # 9
= 8 for production district # 10
= 9 for production district # 11
= 10 for production district # 12
= 11 for production district # 13
= 12 for production district # 14
= 13 for production district # 15
= 14 for production district # 16 and 17
= 15 for production district # 18
= 16 for production district # 19
= 17 for production district # 20
= 18 for production district # 21
= 19 for production district # 22 and 23

IAC = Ash content (% A) of bituminous coal shipped from production district/district grouping p for use by industrial sources

IPA is computed using the formula:

$$IPA = \sum_{n=1}^{SCC} FACI_n \cdot IPBS_n$$

where: SCC = AIRS Facility points for SCCs 1-03-002-** and 1-03-003-**
FACI = Ash content of bituminous coal at industrial point sources in the AIRS/FS Point Source Data Files[20] summed by State
IPBS = Annual throughput of bituminous coal at industrial point sources in the AIRS/FS Point Source Data Files[20] summed by State

IPB is computed as follows:

$$IPB = \sum_{n=1}^{SCC} IPBS_n$$

where: SCC = AIRS Facility points for SCCs
1-02-002-**
1-02-003-**
3-90-002-**
3-90-003-**
IPBS = Annual throughput at industrial point sources in the AIRS/FS Point Source Data Files[20] summed by State

SECTION 4

MOBILE SOURCES

Mobile sources which contribute to area source emissions are divided into the following five major categories: Highway Vehicles, Off-Highway Vehicles, Railroad Locomotives, Aircraft, and Marine Vessels. For each of the above categories, methodologies for activity level and emission factor estimation are discussed.

HIGHWAY VEHICLES

AMS segregates motor vehicles into the following eight EPA vehicle categories on the basis of use and gross vehicle weight for the purpose of calculating emissions:

• Light-Duty Gasoline Vehicles (≤ 8,500 lb)	LDGV
• Light-Duty Gasoline Trucks - 1 (≤ 6,000 lb)	LDGT1
• Light-Duty Gasoline Trucks - 2 (> 6,000 & ≤ 8,500 lb)	LDGT2
• Heavy-Duty Gasoline Vehicles (> 8,500 lb)	HDGV
• Motorcycles (3 wheels or less and < 1,500 lb)	MC
• Light-Duty Diesel Vehicles (≤ 8,500 lb)	LDDV
• Light-Duty Diesel Trucks (≤ 8,500 lb)	LDDT
• Heavy-Duty Diesel Vehicles (> 8,500 lb)	HDDV

LDGV are defined as gasoline powered passenger vehicles weighing 8,500 pounds or less. LDGT1 include gasoline cargo vehicles weighing 6,000 pounds or less. LDGT2 include gasoline cargo vehicles weighing between 6,001 and 8,500 pounds. Heavy-duty vehicle categories separate diesel and gasoline powered trucks and buses weighing more than 8,500 pounds. Motorcycles are defined as any motor vehicle designed to travel with not more than three wheels in contact with the ground, and weighing less than 1,500 pounds. LDDV are defined as diesel powered passenger vehicles weighing 8,500 pounds or less. LDDT include diesel cargo vehicles weighing 8,500 pounds or less.

While vehicle miles travelled (VMT) are determined for each vehicle class and road class, fuel consumption is determined only for each vehicle class. Emission factors in grams per mile obtained from the execution of the MOBILE[28] model are applied so as to determine emissions for vehicle type and speed class. VMT is determined for the following road classes:

Assumed Speed (mph)	Road Class
55	Urban Interstate
55	Rural Interstate
55	Urban Other Freeways and Expressways
55	Urban Other Principal Arterials
55	Rural Other Principal Arterials
55	Urban Minor Arterials
55	Rural Minor Arterials
45	Rural Major Collector
45	Rural Minor Collector
45	Rural Local
19.6	Urban Collector
19.6	Urban Local

Development of Fractional Distribution of VMT by Road Class and Vehicle Type (Speed Class File)

The algorithm used to compute the fractional distribution of VMT by road class assumes that the VMT by functional class for a given county is proportional to that county's road miles by functional class. These fractional distributions are applied to the normalized VMT by county (discussed in the next section) to calculate the VMT by vehicle type and functional road class used to estimate vehicle emissions.[29] The methodology to calculate the fractional distribution of county VMT differs for HDDV since much of the VMT of these vehicles is accrued outside the county of registration.

County road miles by functional class may be obtained from the Federal Highway Administration (FHWA).[30] State VMT by functional class is reported in Highway Statistics.[31]

In order to compute the Fractional Distribution of County VMT by road class/speed class i ($FCVMT_{i,T}$) for all vehicle types other than HDDV, the following equations are used:

$$FCVMT_{i,T} = \frac{SVMT_i \cdot \frac{CRM_i}{SRM_i}}{\sum_{m=1}^{c} \sum_{n=1}^{i} SVMT_{n,m} \cdot \frac{CRM_{n,m}}{SRM_{n,m}}}$$

where: $FCVMT_{i,T}$ = Estimated fractional distribution of county VMT by road class/speed class i

$SVMT_i$ = Published total of State VMT by functional class (from Highway Statistics[31])

i = Functional Road Class
(Interstate Rural
Other Principal Arterial Rural
Minor Arterial Rural

		Major Collector Rural Minor Collector Rural Local Rural Interstate Urban Other Freeways and Expressways Urban Other Principal Arterial Urban Minor Arterial Urban Collector Urban Local Urban)
T	=	1 for LDGV 2 for LDGT 1 3 for LDGT 2 4 for HDGV 5 for MC 6 for LDDV 7 for LDDT
CRM_i	=	Road mileage by county for functional road class i [30]
SRM_i	=	Road mileage by State for functional road class i [30]
c	=	number of counties in the State

Since HDDV behavior is often characterized by cross-country travel, many of the VMT of these vehicles are accrued outside the county of registration. To account for this behavior, VMT (and fuel consumption) estimates are calculated separately for long-range travel and short-range travel.[29]

The annual miles travelled and percentage of the miles travelled outside the State for all diesel trucks weighing at least 8,500 pounds (gross vehicle weight) are extracted from the data in the Truck Inventory and Use Survey (TIUS)[32]. VMT categories are estimated using the above data and the following equations:

Total VMT	=	annual miles · stratum expansion factor
Long Range VMT	=	annual miles · percent of travel outside State · stratum expansion factor
Short Range VMT	=	Total VMT - Long Range VMT

The stratum expansion factor is a ratio used to expand the vehicle data from the sample size in TIUS to each State's vehicle populations. State long range totals are summed to form the national HDDV long range VMT pool.

The national long range VMT pool is then allocated to the county level according to the fraction of the total State mileage of the National Network located within each county line. The National Network is a set of highways on which large trucks are ensured travel rights. Since data are available on county roadway mileage by functional class, and the National Network is a subset of Federal Aid Primary (FAP) System, State totals of National Network mileages are allocated to counties on the basis of county mileage of each of the major FAP functional classes: Interstate, Major Arterials, and Freeways.[31]

Short range VMT is allocated to the county level on the basis of truck registrations. Short range VMT and long range VMT are then totalled for each county.

Since the behavior of HDDV differs significantly from that of other vehicle types, VMT is allocated to speed classes (limited access, urban, and rural) in a different manner. Each county's HDDV long range VMT is assumed to occur on limited access roads; short range HDDV VMT is divided equally between rural and urban roads.

Registration data and National Network mileage are taken from FHWA Highway Statistics.[31] County roadway mileages by functional class are also obtained from FHWA.[30] VMT measurements are obtained from the TIUS.[32]

The fraction of HDDV (vehicle type 8) county VMT due to long range travel for functional road class i ($FCVMT_{i,8,lr}$) is computed below:

$$FCVMT_{i,8,lr} = \frac{SLRVMT_i \cdot \frac{CLRM_i}{SLRM_i}}{\sum_{m=1}^{c} \sum_{n=1}^{i} SLRVMT_{n,m} \cdot \frac{CLRM_{n,m}}{SLRM_{n,m}}}$$

where:

$FCVMT_{i,8,lr}$	=	Estimated fraction of HDDV county VMT for functional road class i
$SLRVMT_i$	=	Sum of functional class road miles (i) within a State considered to be long range [32]
i	=	Functional Road Class (Interstate Rural Other Principal Arterial Rural Minor Arterial Rural Interstate Urban Other Freeways and Expressways Urban Other Principal Arterial Urban)
8	=	HDDV
lr	=	1 = Long Range
$CLRM_i$	=	Road mileage by county for functional road class (i) considered to be long range [30]
$SLRM_i$	=	Road mileage by State for functional road class (i) considered to be long range [30]

The fraction of HDDV county VMT due to short range travel for functional road class i ($FCVMT_{i,8,sr}$) is computed below:

$$FCVMT_{i,8,sr} = \frac{SSVMT_i \cdot \frac{CSRM_i}{SSRM_i}}{\sum_{m=1}^{c} \sum_{n=1}^{i} SSVMT_{n,m} \cdot \frac{CSRM_{n,m}}{SSRM_{n,m}}}$$

where: $SSVMT_i$ = Sum of functional class road miles (i) within a State considered to be short range [32]

i = Functional Road Class
(Major Collector Rural
Minor Collector Rural
Local Rural
Minor Arterial Urban
Collector Urban
Local Urban)

8 = HDDV

sr = 2 = Short Range

$CSRM_i$ = Road mileage by county for functional road class (i) considered to be short range [30]

$SSRM_i$ = Road mileage by State for functional road class (i) considered to be short range [30]

County VMT by Vehicle Type--

The original methodology for computing VMT and fuel consumption for highway vehicles was very complex and very difficult to utilize[11]. However, the methodology used for AMS has been simplified without abandoning the basic concept altogether. That is, VMT and fuel consumption are interrelated. Currently, the basic concept for computing VMT and fuel consumption for highway vehicles is adapted from the MOBILE3 Fuel Consumption Model[33]. While the MOBILE3 Fuel Consumption Model uses a moderately complex methodology to compute VMT and fuel consumption for highway vehicles, the AMS methodology uses the same basic concept while maintaining a certain simplicity. AMS attempts to use published data as benchmarks for the methodology whenever possible (e.g., VMT and fuel consumption data as reported in Highway Statistics[31], VMT as reported by State Departments of Transportation).

VMT by vehicle type is obtained by multiplying the number of vehicles by vehicle type by model year in each county by a mileage accumulation rate by model year. This estimated county VMT by vehicle type is then normalized. The methodology for normalizing this VMT differs depending on the availability of county-level measured-VMT from the State Department of Transportation (DOT). If this is available, the VMT estimates are normalized based on these data. If State DOT VMT is not available, the VMT is normalized for the appropriate State based on the State-by-State VMT reported in Highway Statistics.[31]

Total State annual VMT estimates are found in Federal Highway Administration Highway Statistics.[31] County-level registrations are obtained from the R. L. Polk Company.[34] Mileage accumulation rates for each vehicle type by age are obtained from the latest version of the MOBILE[28] model.

An estimate of county VMT by functional road class i and vehicle type T ($ALLCVMT_{i,T}$) (1000 VMT) is computed as follows:

$$ALLCVMT_{i,T} = FCVMT_{i,T} \cdot NCVMT_T$$

where: $ALLCVMT_{i,T}$ = Estimated county VMT by functional road class i and vehicle type T

$FCVMT_{i,T}$	=	Fractional distribution of county VMT by road class/speed class i,T (see previous section "Development of Fractional Distribution of VMT by Road Class and Vehicle Type")
$NCVMT_T$	=	Normalized estimate of the county VMT by vehicle type T (computed below)
T	=	1 for LDGV 2 for LDGT 1 3 for LDGT 2 4 for HDGV 5 for MC 6 for LDDV 7 for LDDT

The allocation of HDDV VMT to speed classes is different, and an estimate of county VMT by functional road class i and vehicle type 8 (HDDV) ($ALLCVMT_{i,8}$) (1000 VMT) is computed as follows:

$$ALLCVMT_{I,8} = FCVMT_{I,8,r} \cdot NCVMT_{8,r} \cdot CDFRACT_r$$

where:	$FCVMT_{i,8,r}$	=	Fractional distribution of VMT to road class/speed class (i) for vehicle type (T) -- HDDV (see "Development of Fractional Distribution of VMT by Road Class and Vehicle Type")
	$NCVMT_{8r}$	=	Normalized estimate of county VMT for HDDV (computed below)
	$CDFRACT_r$	=	Fraction of heavy-duty diesel VMT by county for range (r)
	r	=	1 = Long Range 2 = Short Range

The fraction of short range HDDV VMT by county ($CDFRACT_2$) is calculated as follows:

$$CDFRACT_2 = 1 - CDFRACT_1$$

The fraction of long range HDDV VMT by county ($CDFRACT_1$) is calculated as follows:

$$CDFRACT_1 = \frac{(CNNF \cdot NLRVMT)}{\left(\frac{CT}{ST} \cdot SSRVMT\right) + (CNNF \cdot NLRVMT)}$$

where:	CNNF	=	Fraction of national network truck miles by county (computed below)
	NLRVMT	=	National total of HDDV VMT outside of the State of registration[32]
	CT	=	Number of trucks in county > 26,000 lb

ST	=	Number of trucks in State > 26,000 lb
SSRVMT	=	HDDV VMT within the State of registration[32]

Normalized Estimates of County VMT by Vehicle Type with State DOT VMT -- Normalized county estimates of VMT by highway vehicle type T ($NCVMT_T$) (1000 VMT) is computed by the following equation if county-level VMT are obtained from the State DOT:

$$NCVMT_T = \frac{ECVMT_T}{\sum_{n=1}^{T} ECVMT_n} \cdot CVM$$

where:	$NCVMT_T$	=	Normalized estimated county VMT by highway vehicle type T
	$ECVMT_T$	=	Estimated county VMT for vehicle type T (computed below)
	T	=	1 for LDGV 2 for LDGT 1 3 for LDGT 2 4 for HDGV 5 for MC 6 for LDDV 7 for LDDT 8 for HDDV
	CVM	=	Annual VMT in county as reported by the State DOT

The equation to compute an estimate of county VMT ($ECVMT_T$) for vehicle types other than HDDV (T=8) is as follows:

$$ECVMT_T = \frac{\sum_{n=1}^{A} VR_{n,T,c} \cdot MAR_{n,T}}{\sum_{m=1}^{c} \sum_{p=1}^{T} \sum_{n=1}^{A} VR_{n,p,m} \cdot MAR_{n,p}}$$

where:	T	=	1 for LDGV 2 for LDGT 1 3 for LDGT 2 4 for HDGV 5 for MC (See Motorcycle Section) 6 for LDDV 7 for LDDT
	$VR_{A,T,c}$	=	Vehicle registrations for vehicle age (A) 1 through 20, vehicle type (T), and county (c)
	$MAR_{A,T}$	=	Mileage accumulation rate for vehicle age (A) 1 through 20 and vehicle type (T)

An estimate of county HDDV VMT ($ECVMT_8$) is calculated using the equation:

$$ECVMT_8 = \left(\frac{CT}{ST} \cdot SSRVMT\right) + (CNNF \cdot NLRVMT)$$

where:
- CT = Number of trucks in county > 26,000 lb[34]
- ST = Number of trucks in State > 26,000 lb [34]
- SSRVMT = HDDV VMT within the State of registration[32]
- CNNF = Fraction of national network truck miles by county (computed below)
- NLRVMT = National total of HDDV VMT outside of the State of registration[32]

CNNF is calculated using the formula:

$$CNNF = \frac{\frac{CFPM}{\sum_{n=1}^{c} CFPM_n} \cdot SNN}{NNM}$$

where:
- CFPM = Miles of FAP road by county (computed below)
- SNN = Amount of national network truck mileage in a State[31]
- NNM = National total national network truck mileage[31]

The equation to compute CFPM is as follows:

CFPM =
- Interstate Rural +
- Interstate Urban +
- Other Principal Arterial Rural +
- Other Principal Arterial Urban +
- Other Freeways & Expressways Urban[30]

Normalized Estimates of County VMT by Vehicle Type without State DOT VMT – Normalized county estimates of VMT by highway vehicle type T ($NCVMT_T$) (1000 VMT) is estimated by the following equation if county-level VMT is NOT obtained from the State DOT:

$$NCVMT_T = \frac{ECVMT_T}{\sum_{n=1}^{c}\sum_{m=1}^{T} ECVMT_{m,n}} \cdot SVM$$

where:
- $ECVMT_T$ = Estimated county VMT for vehicle type T (computed below)
- T = 1 for LDGV

2 for LDGT 1
3 for LDGT 2
4 for HDGV
5 for MC
6 for LDDV
7 for LDDT
8 for HDDV

SVM = Published total of State VMT[31]

The equation to compute an estimate of county VMT ($ECVMT_T$) for vehicles other than HDDV (T=8) is as follows:

$$ECVMT_T = \frac{\sum_{n=1}^{A} VR_{n,T,c} \cdot MAR_{n,T}}{\sum_{m=1}^{c} \sum_{p=1}^{T} \sum_{n=1}^{A} VR_{n,p,m} \cdot MAR_{n,p}}$$

where: T = 1 for LDGV
2 for LDGT 1
3 for LDGT 2
4 for HDGV
5 for MC (see Motorcycle Section)
6 for LDDV
7 for LDDT

$VR_{A,T,c}$ = Vehicle registrations for vehicle age (A) 1 through 20, vehicle type (T), and county (c)

$MAR_{A,T}$ = Mileage accumulation rate for vehicle age (A) 1 through 20 and vehicle type (T)

An estimate of county HDDV VMT ($ECVMT_8$) is calculated using the equation:

$$ECVMT_8 = \left(\frac{CT}{ST} \cdot SSRVMT\right) + (CNNF \cdot NLRVMT)$$

where: CT = Number of trucks in county > 26,000 lb[34]

ST = Number of trucks in State > 26,000 lb[34]

SSRVMT = HDDV VMT within the State of registration[32]

CNNF = Fraction of national network truck miles by county (computed below)

NLRVMT = National total of HDDV VMT outside of the State of registration[32]

CNNF is computed using the formula:

$$CNNF = \frac{\frac{CFPM}{\sum_{n=1}^{c} CFPM_n} \cdot SNN}{NNM}$$

where: CFPM = Miles of FAP road by county (computed below)
SNN = Amount of national network truck mileage in a State[31]
NNM = Total national network truck mileage

CFPM is computed using the equation:

CFPM = Interstate Rural +
Interstate Urban +
Other Principal Arterial Rural +
Other Principal Arterial Urban +
Other Freeways and Expressways Urban

Gasoline-Powered Vehicles: Fuel Consumption Methodology

Gasoline consumption of LDGV, LDGT1, LDGT2, HDGV, and MC is determined by allocating total State highway gasoline consumption to the county level, based on VMT and miles per gallon (mpg) values for the appropriate vehicle types.[31]

Total gasoline consumption reported for each State is allocated to counties using the normalized VMT by vehicle type ($NCVMT_T$) as discussed in the previous section. The normalized VMT by vehicle type was calculated by one of two methods depending on the availability of State-submitted data for VMT in each county. VMT is normalized using State DOT VMT estimates where available (see previous section). For States where data were not available, the VMT is normalized based on the State-by-State VMT reported in Highway Statistics[31] (see previous section). A miles per gallon value is applied to the normalized VMT by vehicle type, and this value is used to distribute total State highway gasoline consumption to counties.[31]

Total State highway gasoline consumption, State annual VMT, and fuel efficiency estimates are found in Federal Highway Administration Highway Statistics.[31] County-level registrations are obtained from the R. L. Polk Company.[34] Mileage accumulation rates for each vehicle type by age are obtained from the latest version of the MOBILE[28] model.

County gasoline consumption by highway vehicle type T ($CHGC_T$) (1000 gallons) is estimated by the following equation:

$$CHGC_T = \left[\frac{NCVMT_T \cdot MPG_T}{\sum_{n=1}^{c} \sum_{m=1}^{T} (NCVMT_{m,n} \cdot MPG_{m,n})} \right] \cdot TSH$$

where: $CHGC_T$ = Estimated county gasoline consumption by highway vehicle type T

$NCVMT_T$ = Normalized estimate of county-level VMT for vehicle type T

MPG_T = Average mpg of fuel consumed[31]

TSH = Published total State highway gasoline consumption[31]

T = 1 for LDGV
2 for LDGT 1
3 for LDGT 2
4 for HDGV
5 for MC

c = number of counties in State

The normalized estimate of county VMT is as previously calculated in "County VMT by Vehicle Type."

Diesel-Powered Vehicles: Fuel Consumption Methodology

In general, diesel consumption of LDDV, LDDT, and HDDV is determined by allocating total State highway diesel consumption to the county level based on VMT and miles per gallon values for the appropriate vehicle types. Since HDDV behavior is often characterized by cross-country travel, much of the fuel consumption of these vehicles is accrued outside the county of registration. This is accounted for in the methodology used to calculate the HDDV VMT as discussed in the previous sections.

The VMT estimates used to calculate fuel consumption are estimated in one of two ways depending on the availability of county-level measured VMT data. If this is available, the VMT is normalized based on the State DOT VMT as discussed in subsection "Normalized Estimates of County VMT by Vehicle Type with State DOT VMT." Otherwise, VMT is normalized based on the appropriate State VMT reported in Highway Statistics[31], as discussed in subsection "Normalized Estimates of County VMT by Vehicle Type without State DOT VMT." A miles per gallon value is applied to the normalized VMT by vehicle type and this value is used to distribute total State highway diesel consumption to counties.[31]

Total State highway diesel consumption and fuel efficiency estimates are found in Federal Highway Administration Highway Statistics.[31]

County diesel consumption by highway vehicle type T ($CHDC_T$) (1000 gallons) is estimated by the following equation:

$$CHDC_T = \left[\frac{NCVMT_T \cdot MPG_T}{\sum_{n=1}^{c} \sum_{m=6}^{T} (NCVMT_{m,n} \cdot MPG_{m,n})} \right] \cdot SHD$$

where: $CHDC_T$ = County diesel consumption by highway vehicle type T
$NCVMT_T$ = Normalized estimate of county-level VMT for diesel vehicles (see "County VMT by Vehicle Type")
MPG_T = Average mpg of fuel consumed[31]
SHD = Published total State highway diesel consumption[31]
T = 6 for LDDV
7 for LDDT
8 for HDDV

Motorcycle Registration Estimates by Vehicle Age

An estimate of motorcycle registrations by county by age ($VR_{5,A}$) is estimated with the following equation:

$$VR_{5,A} = SMH \cdot \frac{CP}{SP} \cdot MRM_A$$

where: $VR_{5,A}$ = Estimated county motorcycle registrations by age
SMH = State motorcycle population for highway use [from Motorcycle Statistical Annual[35]]
CP = Current county population
SP = Current State population
MRM_A = Motorcycle registration mix by age [from MOBILE[28] model]

Emission Factors

Emission factors for highway vehicles are computed using EPA's MOBILE[28] model. The model is run with the following standard inputs to compute county-specific emission factors for each vehicle class:

1. County-specific vehicle registrations by model year and vehicle class, as obtained from R. L. Polk Company;[34]

2. MOBILE[28] default values for mileage accumulation distributions;

3. No use of special correction factors for air conditioning, vehicle load, trailer towing, or humidity;

4. VOC emission factors computed on a non-methane basis;

5. No modification of MOBILE standard trips/day or miles/day data;

6. MOBILE default values for tampering rates (no credits for anti-tampering programs are considered).

For each county, MOBILE scenario records are input to specify:

1. The location of the county in a low altitude or high altitude region. (For California, the model is run for "low altitude" with modified basic exhaust emission rates by model year to correspond to California emission standards. These data are provided by the California Air Resources Board.)[36]

2. Average vehicle speeds of 55, 45, and 19.6 mph, corresponding to the road categories for which VMT have been estimated for each county. (For 19.6 mph roads, standard values of 20.6 percent of VMT accumulated in cold-start mode and 27.3 percent of VMT accumulated in hot-start mode are used. For 55 mph roads, the percent of VMT accumulated in both cold- and hot-start modes are assumed to be zero. For 45 mph roads, percentages for the most current year will be calculated when data become available, by assuming the standard values for 19.6 mph roads for local rural roads and zero for rural collector roads.)

3. An annual average ambient temperature typical of a weather station near the centroid of a State. (The same temperature is used for all counties in a State.)

4. The impact of county inspection/maintenance (I/M) programs. (For counties where I/M programs are in effect, data to estimate the impact of such programs are supplied by the EPA Office of Mobile Sources.[28])

OFF-HIGHWAY SOURCES

Emissions from off-highway vehicles are generated by activities of gasoline and diesel vehicles which do not utilize road systems. Vehicles contributing to off-highway emissions are divided into five general categories: farm equipment, construction equipment, industrial equipment, lawn and garden equipment, and recreational vehicles which include off-highway motorcycles and snowmobiles. While gasoline is consumed by all five categories, diesel fuel is utilized only by farm equipment, construction equipment, and industrial equipment.

In general, consumption is estimated by one of the following methods:

1. Apportionment of national fuel consumption to counties on the basis of employment, population, etc.

2. Calculation of county or State totals by applying fuel consumption rates to average usage figures and equipment populations.

Consumption estimation methodologies are described below for each category by fuel type.

Farm Equipment

State consumption of gasoline and diesel fuel by farm equipment is apportioned to individual counties based on county tractor population data. To estimate State fuel consumption by farm

equipment, consumption values are calculated separately for each of five subcategories: farm tractors, combines, motorized balers, forage harvesters, and general purpose large utility engines. Consumption by fuel type is calculated using subcategory State population, average annual usage (hours per year), and average hourly consumption by fuel type per unit (gallons per hour).[11,35] For diesel fuel, the sum of the estimated fuel use for all subcategories is normalized to agree with published State totals for agricultural diesel fuel use found in DOE Fuel Oil and Kerosene Sales.[12] Total State consumption is then allocated to the county level according to the ratio of county tractor population to State tractor population.

Average annual usage and average hourly consumption are extracted from Exhaust Emissions from Uncontrolled Vehicles and Related Equipment Using Internal Combustion Engines.[37] With the exception of general purpose large utility engines, State and county equipment populations are obtained from Census of Agriculture-State and County Data.[38] Large utility engine populations are estimated in an algorithm which uses State tractor population and the number of irrigated and non-irrigated farms obtained from Census of Agriculture-Summary and State Data.[39]

For all gasoline-consuming categories, it is assumed that 91.8 percent of total hydrocarbon is reactive VOC. This fraction is based on the VOC Species Data Manual, Profile 90-6021D.[40] For all diesel consuming categories, a value of 95.2 percent of total hydrocarbon is assumed to be reactive VOC based on Profile 90-7021.

Off-Highway Gasoline: Farm Equipment Equations –

A normalized estimate of County Gasoline Consumption by Farm Equipment (NCFG) (1000 gallons) is computed as follows:

$$NCFG = ECFG \cdot \frac{SGF}{\sum_{n=1}^{c} ECFG_n}$$

where: NCFG = Normalized estimated county gasoline consumption by farm equipment
ECFG = Estimated county gasoline consumption by farm equipment (computed below)
SGF = Reported State agricultural gasoline consumption
c = Number of counties in the State

$$ECFG = \frac{\sum_{n=1}^{k} f_n \cdot CE_n \cdot A_n \cdot FR_n}{1000}$$

where: f = Fraction of farm equipment that is powered by gasoline
k = Equipment type
(1 for tractors
2 for combines
3 for balers

		4 for large general purpose engines)
CE	=	County population of farm equipment
A	=	Average annual usage (hours/year) of farm equipment
FR	=	Average consumption (gallons/hour) of gasoline per unit of equipment

The formula used to compute county population of large general purpose engines (CE_4) is:

$$CE_4 = \left(0.03 \cdot TC \cdot \frac{IFC}{FC} \right) + \left(0.05 \cdot TC \cdot \frac{FC - IFC}{FC} \right)$$

where:	TC	=	County tractor population
	IFC	=	Number of farms in State in irrigated areas
	FC	=	Number of farms in State with market value of crops sold > $2500

Off-Highway Diesel: Farm Equipment Equations –

An estimate of County Diesel Consumption by Farm Equipment (ECFD) (in 1000 gallons) is calculated as follows:

$$ECFD = \frac{TC}{TS} \cdot SDF$$

where:	ECFD	=	Estimated county diesel consumption by farm equipment
	TC	=	County tractor population
	TS	=	State tractor population
	SDF	=	Reported State farm use of diesel

Off-Highway: Farm Equipment Emission Factors –

Emission factors for gasoline and diesel farm tractors and other farm equipment are obtained separately from AP-42, Table II-6-2.[8] Large utility equipment emission factors are also taken from AP-42, Table 3.1-2.

Construction Equipment

The method used to determine consumption of gasoline and diesel fuel by construction equipment distributes State gasoline and diesel fuel consumption to the county level based on employment. For the purposes of this algorithm, total non-building construction employment is the sum of the employment of heavy construction (SIC category 16) and special trade (SIC category 17) industries. County consumption of fuel is then allocated from State construction consumption based on the ratio of county employment of heavy construction (SIC category 16) and special trade (SIC category 17) industries to State employment for those same SIC categories.

Estimates of State gasoline consumption are obtained from the DOT publication Highway Statistics.[31] For diesel fuel, published State totals are reported by DOE in the Fuel Oil and Kerosene Sales report.[12] Annual employment data are extracted from the Census Bureau's County Business Patterns.[22]

Off-Highway Gasoline: Construction Equipment Equations --

An estimate of County Gasoline Consumption by Construction Equipment (CGCE) (in 1000 gallons) is calculated as follows:

$$CGCE = \frac{CCE}{SCE} \cdot SCG$$

where:	CGCE	=	Estimated county gasoline consumption by construction equipment
	CCE	=	County employment in heavy construction
	SCE	=	State employment in heavy construction
	SCG	=	Reported State construction use of gasoline

Off-Highway Diesel: Construction Equipment Equations --

An estimate of County Diesel Consumption by Construction Equipment (ECCD) (in 1000 gallons) is calculated as follows:

$$ECCD = \frac{CCE}{SCE} \cdot SCD$$

where:	ECCD	=	Estimated county diesel consumption by construction equipment
	CCE	=	County employment in heavy construction
	SCE	=	State employment in heavy construction
	SCD	=	Reported State construction use of diesel

Off-Highway: Construction Equipment Emission Factors --

Emission factors from AP-42[8] are weighted separately for diesel fuel (Table II-7.1) and gasoline (Table II-7.2) equipment using consumption data from the Procedures Document, Table 3.5-1.[41]

Industrial Equipment

The methodology involves apportioning national industrial fuel consumption according to relative differences in labor productivity of three industries.[11] The algorithm compares combined county employment to the combined State employment of manufacturing (SIC categories 20 through 39), mining (SIC 10 through 14), and wholesale trade industries (SIC 50).

Estimates of State gasoline consumption due to industrial equipment are obtained from DOT's Highway Statistics[31], and estimates of State diesel consumption due to industrial equipment are obtained from DOE's Fuel Oil and Kerosene Sales report.[12] Total employment in manufacturing,

mining, and wholesale trade is the sum of figures reported in Bureau of Census County Business Patterns[22] for SIC categories 20 through 39, 10 through 14, and 50, respectively.

Off-Highway Gasoline: Industrial/Commercial Equipment Equations --

An estimate of County Gasoline Consumption by Industrial/Commercial Equipment (CGIC) (in 1000 gallons) is calculated as follows:

$$CGIC = SICG \cdot \frac{(CMF + CME + CWE)}{(SMF + SME + SWE)}$$

where:
- CGIC = Estimated county gasoline consumption by industrial/commercial equipment
- SICG = State gasoline consumption due to industrial/commercial equipment
- CMF = Total county employment in manufacturing (SIC 20 through 39)
- CME = Total county employment in mining (SIC 10 through 14)
- CWE = Total county employment in wholesale trade (SIC 50)
- SMF = Total State employment in manufacturing (SIC 20 through 39)
- SME = Total State employment in mining (SIC 10 through 14)
- SWE = Total State employment in wholesale trade (SIC 50)

Off-Highway Diesel: Industrial/Commercial Equipment Equations --

An estimate of County Diesel Consumption by Industrial/Commercial Equipment (ECDIC) (in 1000 gallons) is calculated as follows:

$$ECDIC = SICD \cdot \frac{(CMF + CME + CWE)}{(SMF + SME + SWE)}$$

where:
- ECDIC = Estimated county diesel consumption by industrial/commercial equipment
- SICD = State diesel consumption due to industrial/commercial equipment -- (computed below)
- CMF = Total county employment in manufacturing (SIC 20 through 39)
- CME = Total county employment in mining (SIC 10 through 14)
- CWE = Total county employment in wholesale trade (SIC 50)
- SMF = Total State employment in manufacturing (SIC 20 through 39)
- SME = Total State employment in mining (SIC 10 through 14)
- SWE = Total State employment in wholesale trade (SIC 50)

$$SICD = OFFHIGHWAY\ DIESEL{:}OTHER + MILITARY\ USE{:}DIESEL$$

Off-Highway: Industrial/Commercial Equipment Emission Factors --

Emission factors for industrial equipment are taken directly from AP-42, Table 3.1-2.[8]

Lawn and Garden Equipment

The original methodology involves allocation of national consumption of gasoline by lawn and garden equipment to individual counties.[37] Regression analyses yielded an algorithm in which county apportionment is based on the number of single-unit dwelling structures, the number of freeze-free days (i.e., minimum average temperature higher than 32°F), the fraction of national snow zone population in the county (all areas with an annual snowfall greater than 30 inches), snowthrower fuel consumption rate, average snow removal rate, and county snowfall.

Annual weather data including freeze-free days and county snowfall are reported monthly for selected representative weather stations in each county in NOAA's Climatological Data.[6] The number of dwelling units in single structures is available in the Census Bureau's decennial Census of Housing.[4] Current county population is available from the Bureau of Census Current Population Reports.[15] National gasoline consumption is estimated by using calculations based on Exhaust Emissions from Uncontrolled Vehicles and Related Equipment Using Internal Combustion Engines.[37]

Off-Highway Gasoline: Lawn & Garden Equipment Equations --

A normalized estimate of the County Gasoline Consumption by Lawn and Garden Equipment (NCGLG) (in 1000 gallons) is computed as follows:

$$NCGLG = ECGLG \cdot \frac{TNLG}{\sum_{n=1}^{x} ECGLG_n}$$

where: NCGLG = Normalized estimated county gasoline consumption by lawn and garden equipment
ECGLG = Estimated county gasoline consumption by lawn and garden equipment (computed below)
TNLG = Total national gasoline consumption by lawn and garden equipment (computed below)
x = Number of counties in nation

$$TNLG = NLG + NSG$$

where: NLG = National gasoline consumption by lawn and garden equipment other than snowthrowers (computed below)
NSG = National gasoline consumption by snowthrowers (computed below)

The formula used to compute (NLG) is:

$$NLG = 553 \cdot 10^{6} Gallons \cdot \frac{NSU}{58{,}255{,}000}$$

where: NSU = number of dwelling units in single unit structures

The formula used to compute (NSG) is:

$$NSG = NLG \cdot 0.05$$

The formula used to compute (ECGLG) is:

$$ECGLG = CNLG + CNSG$$

where: CNLG = Estimated county gasoline consumption by lawn and garden equipment other than snowthrowers
CNSG = Estimated county gasoline consumption by snowthrowers

The formula used to compute (CNLG) is:

$$CNLG = NLG \cdot \frac{CSU}{NSU} \cdot \frac{CFF \cdot 3174}{NFF}$$

where: CSU = Number of dwelling units in single unit structures in county
NSU = Number of dwelling units in single unit structures in nation
CFF = Number of freeze-free days in county
NFF = Number of freeze-free days in nation

The formula used to compute (CNSG) is:

$$CNSG = NSG \cdot \frac{CP}{SZP} \cdot \frac{CS \cdot 3174}{SZS} \cdot K$$

where: CP = Current county population
SZP = Snow-zone population
CS = County snowfall
SZS = Snow-zone snowfall
K = 0 if CS ≤ 30 inches
1 if CS > 30 inches

Off-Highway Gasoline: Lawn and Garden Equipment Emission Factors --

Emission factors for gasoline powered lawn and garden equipment are taken directly from the small general utility engines section of AP-42, Table II-5-1.[8]

Recreational Vehicles

Emissions from recreational vehicles are generated by activities of gasoline vehicles which do not generally utilize road systems. Recreational vehicles contributing to off-highway emissions are currently divided into two categories: motorcycles and snowmobiles. The following discussions describe how AMS develops emission estimates for the individual components of this category and combines the results to obtain a total for the category of recreational vehicles.

Off-Highway Motorcycles --

The original algorithm estimated county level gasoline consumption based on population, State motorcycle registrations, average annual usage (miles per year), and average fuel consumption rate (gallons per mile).[37] A later refinement to this method involved separating off-road and combined use motorcycles and weighting the distribution of the two types according to regional variations for allocation.[3]

State motorcycle vehicle registration data, national usage rate, factors for the two types of motorcycles, and national fuel consumption rate for both off-road and combination use motorcycles are available from FHWA Highway Statistics[31] and the Motorcycle Statistical Annual.[35] Current county population statistics are obtained from the Bureau of Census Current Population Reports.[15]

Snowmobiles --

County consumption of gasoline by snowmobiles is derived from the national snowmobile gasoline consumption total allocated on the basis of county snowmobile population. To estimate county level snowmobile population, a set of regression formulations is used to relate the percent of State snowmobiles used in the county to population and snowfall.[37] To reflect the impact of population density on snowmobile usage, different algorithms are used to calculate usage in counties with population densities greater and less than 1000 per square mile. A factor reflecting the ratio of average county snowfall to snowfall received in the center of the State is included in these algorithms due to its significance in the regression analyses.

State snowmobile registration data are available by contacting the International Snowmobile Association.[42] Snowfall statistics for each county and the county centroid for each State are compiled by NOAA.[6] County population statistics are recorded in the Bureau of Census Current Population Reports.[15]

Off-Highway Gasoline: Recreational Vehicle Equations --

An estimate of the County Gasoline Consumption by Recreational Vehicles (CGRV) (1000 gallons) is computed as follows:

$$CGRV = CGM + CGSM$$

where: CGRV = Estimated county gasoline consumption by recreational vehicles

CGM	=	Estimated county gasoline consumption due to motorcycles (computed below)
CGSM	=	Estimated county gasoline consumption due to snowmobiles (computed below)

The formula used to compute (CGM) is:

$$CGM = \frac{\frac{CP}{SP} \cdot SM \cdot \frac{f_1 u_1 + f_2 u_2}{MFR}}{1000}$$

where:	CP	=	Current county population
	SP	=	Current State population
	SM	=	State motorcycle population
	f_1	=	Fraction of motorcycles that are off-road (computed below)
	u_1	=	Average usage (miles/year) of off-road motorcycles
	f_2	=	Fraction of motorcycles that are combination (computed below)
	u_2	=	Average usage (miles/year) of combination motorcycles
	MFR	=	Motorcycle fuel consumption rate (miles/gallon)

The formula used to compute (f_1) is:

$$f_1 = \frac{\sum_{n=1}^{sr} ORM_n}{\sum_{n=1}^{sr} (ORM_n + CBM_n + HWM_n)}$$

where:	sr	=	Number of States in census region
	ORM	=	State population of off-road motorcycles
	CBM	=	State population of combination motorcycles
	HWM	=	State population of highway motorcycles

The formula used to compute (f_2) is:

$$f_2 = \frac{\sum_{n=1}^{sr} CBM_n}{\sum_{n=1}^{sr} (ORM_n + CBM_n + HWM_n)}$$

where:	sr	=	Number of States in census region
	CBM	=	State population of combination motorcycles

ORM	=	State population of off-road motorcycles
HWM	=	State population of highway motorcycles

The formula used to compute (CGSM) is:

$$CGSM = NGS \cdot \frac{CSM}{NSM}$$

where:	NGS	=	National gasoline consumption by snowmobiles (computed below)
	CSM	=	County snowmobile population (computed below)
	NSM	=	National snowmobile population

The formula used to compute (NGS) is:

$$NGS = 83 \cdot 10^6 \ Gallons \cdot \frac{NSM}{1{,}715{,}000}$$

where:	NSM	=	National snowmobile population

The formula used to compute (CSM) is:

$$CSM = \frac{f}{\sum_{c=1}^{n} f_c} \cdot SSM$$

where:	f	=	Fraction of State's snowmobiles that are located in the county (computed below)
	n	=	Number of counties in State
	SSM	=	State snowmobile population

The formula used to compute the fraction of the State's snowmobiles that are located in the county (f) is determined by the county's population density and the amount of snowfall the county receives in a given year:

For counties with population densities of less than 1000 per square mile, the formula is:

$$f = \left(1.56 \cdot \frac{CP}{SP}\right) + \left(0.0321 \cdot \frac{CS}{CCS}\right) - 0.0234$$

where:	CP	=	Current county population
	SP	=	Current State population
	CS	=	County snowfall

CCS = Snowfall in State's centroid county

For counties with population densities of more than 1000 per square mile, the formula is:

$$f = X \cdot \frac{CP}{SP} + [1.5 - (0.0005 \cdot CPD)]$$

where: X = 0 if CPD > 3,000
X = 1 if 3,000 ≥ CPD ≥ 1,000
CP = Current county population
SP = Current State population
CPD = County population density

Off-Highway Motorcycle Emission Factors --

Emission factors for gasoline motorcycles are determined utilizing the MOBILE[28] program with the following conditions:

1. County Altitude -- Low
2. Vehicle Speed -- 19.6 mph
3. Ambient Temp. -- 57°F
4. Hot Start/Cold Start Percentage -- Zero
5. All other variables -- Default values

Resulting emission factors in grams per VMT are converted to pounds per 1000 gallons using a unit conversion factor of 20.8.

Snowmobile Emission Factors --

Emission factors for gasoline powered snowmobiles are taken from AP-42, Table II-8-1.[8]

AIRCRAFT

Emissions estimates for aircraft are divided into three categories: commercial aircraft, military aircraft, and civil aircraft. Activity levels and emission factors, measured relative to units of aircraft landing and takeoff cycles (LTOs) by county, are multiplied by emission factors to obtain emissions estimates.

Activity level is measured by LTOs using either operation records from county airports or aircraft registration data, depending on the location of Federal Aviation Administration (FAA) airports. For the purpose of these calculations, an operation, as defined by the FAA, constitutes either a takeoff or landing.

Weighted average emission factors are computed for each type of aircraft within each aviation category. In some categories, flying hours are used as a unit of measure assuming that the number of flying hours is proportional to the number of LTOs. Emission factors are then combined using aircraft type population data from Jane's[43] and FAA Aviation Forecasts[44] to form one factor for each pollutant.

Commercial Aircraft

For counties with FAA regulated airports LTOs are derived separately from reported operations for air carrier and air taxi categories. Locations of FAA regulated airports are obtained from the FAA Air Traffic Activity.[45]

Air Carrier --

County estimates of air carrier LTOs (LTO_{AC}) are calculated using the following formula:

$$LTO_{AC} = 0.5 \cdot O_{AC}$$

where: LTO_{AC} = Estimated county number of air carrier LTOs
O_{AC} = Total operations in county for air carrier

Emission Factors --

Commercial service aircraft emission factors from AP-42,Table II-1-9[8] are updated and weighted from the previous year's data on LTOs from the Procedures Document, Table 3.2.4.[41] and the FAA's Census of U.S. Civil Aircraft.[46] The number of operations in the update year is estimated using the number of aircraft in service for each of the following plane types: BAC 111, Boeing-707, Boeing 727, Boeing 737, Boeing 747, L1011, DC8, DC9, and DC10. The resultant value is compared with the reported update year value obtained from FAA Air Traffic Activity.[45] The weighting factors are applied to the emission factors to produce an average for all plane types.

Air Taxi --

County estimates of air taxi LTOs (LTO_{AT}) are calculated using the following formula:

$$LTO_{AT} = 0.5 \cdot O_{AT}$$

where: LTO_{AT} = County estimates of air taxi LTOs
O_{AT} = Total operations in county for air taxi

Emission Factors --

Air taxi emission factors are weighted averages for emission factors for turbojets, turboprops, and piston planes taken from AP-42, Table II-1-9.[8] Weighting is based on the number of aircraft from FAA's Census of U.S. Civil Aircraft.[46]

Military Aircraft

For counties with FAA regulated airports, LTOs are derived from reported operations for the military aircraft category. In addition, an accounting must be made of military aircraft operations at non-FAA regulated airports. These data, previously published in the FAA's Military Air Traffic Activity[47] report, are still available from the FAA although not in a published report format.

Military --

County estimates of military LTOs (LTO_M) are calculated using the following formula:

$$LTO_M = 0.5 \cdot O_M$$

where: LTO_M = County estimates of military LTOs
O_M = Total operations in county for military

Emission Factors --

Emission factors for each aircraft type are taken from AP- 42, Table II-1-10.[8] Initial emission factors are averaged and weighted by usage and population data. The number of flying hours for single-engine piston planes, multi-engine piston planes, turboprops, turbojets, rotocraft piston planes, and rotocraft turbine planes is obtained from FAA Aviation Forecasts.[44] Average emission factors are weighted by aircraft population data found in Jane's[43] and FAA Aviation Forecasts.[44]

Civilian Aircraft

For counties with no FAA regulated airports or military airports, all operations are assumed to involve civil aircraft only. The number of LTOs are derived using county aircraft registration data. It is assumed each aircraft performs 250 LTOs per year.

The number of active civil aircraft registrations is found in the FAA's Census of U.S. Civil Aircraft.[46]

Civil --

County estimates of civil LTOs (LTO_{CR}) are calculated using the following formula:

$$LTO_{CR} = 0.5 \cdot O_{CR}$$

where: LTO_{CR} = County estimates of civil LTOs
O_{CR} = Total operations in county for civil aircraft

For counties with no FAA-regulated airports or military airports, all operations in the county are assumed to involve civil aircraft only. The number of LTOs for civil aircraft is calculated using county aircraft registrations. The equation is the following:

$$LTO_{CR} = 250 \cdot N$$

where: N = Number of aircraft registered in county

Emission Factors --

Emission factors are determined by the same procedure as in Military Aircraft.

Unpaved Airstrips

Unpaved airstrip emissions are affected by the same primary factors as unpaved roads. Fugitive emissions from unpaved airstrip use are measured by annual LTO cycles on unpaved airstrips in each county. The activity level estimate derived for each county in the AMS is multiplied by an adjusted emission factor to obtain a particulate emissions estimate.

A methodology to measure the activity level by LTO cycles at unpaved airstrips within the county is determined by identifying all airports which have airstrips made of dirt, sand, gravel, or gravel pavement, excluding airports with no based aircraft, airports no longer in operation, heliports, and seaplane bases. The number of aircraft based in each airport is tallied for each county and then multiplied by 250. Local FAA officials estimated the typical number of LTOs of a based aircraft at small airport facilities is 250 per year.[48]

Emission Factors --

The particulate emission factor was obtained from Emissions Inventory of Agricultural Tilling, Unpaved Roads and Airstrips, and Construction Sites.[48] For the purposes of these calculations, average LTO speed is estimated at 40 miles per hour, the length of the runway to complete one LTO is 1 mile, and the wind-erosion multiplier is 2. Surface texture is determined for each State based on the number and type of non-surfaced airstrips and average soil silt content for each county.

MARINE VESSELS

Marine vessel categories for which emissions estimates are discussed include distillate oil vessels, residual oil vessels, and gasoline vessels. Emissions from coal vessels have not been estimated because emissions from this source are considered negligible compared to other area sources. Consumption methodologies and emission factor derivation are presented below for each category. The methods for generating activity level estimates are discussed, and final estimates are presented in gallons of fuel consumed.

Diesel (Distillate) Oil Vessels

Emissions are estimated for marine vessels which use distillate oil (diesel fuel). This category includes large cargo and passenger ships, oil tankers, tugboats, and other steamships and motorships that are known to consume distillate oil. The activity level, measured in thousands of gallons, is multiplied by emission factors to obtain emissions estimates. The methodology requires the updating of the most recent year's estimate with fuel data obtained from "Fuel Use by Vessels Bunkering" in the Fuel Oil and Kerosene Sales report[12] excluding fuel used by ships outside the U.S. continental limits.

The original methodology estimated county level consumption based on number, type, and size of ship, and time spent in port and underway. Consumption by vessels at ports for which consumption data were available was assigned to the port county. The remaining fuel consumption was distributed to ports and waterways according to tonnage handled. Information on fuel sales to vessels was taken from Fuel Oil and Kerosene Sales[12] and ship characteristics were obtained from Waterborne Commerce of the United States.[49]

Diesel (Distillate) Oil Vessel Equations --

County consumption of diesel fuel by marine vessels (MVD) (1000 gallons) is computed using the formula:

$$MVD = PIPD \cdot \frac{CMVD}{\sum_{n=1}^{c} CMVD_n} \cdot SMD$$

where: MVD = County consumption of diesel fuel by marine vessels
PIPD = Percent of diesel fuel consumed within the Continental U.S.
CMVD = County consumption of diesel fuel by marine vessels on AIRS AMS statistical file
c = Number of counties in State
SMD = State deliveries of diesel fuel for use by marine vessels

Diesel (Distillate) Oil Vessel Emission Factors --

Emission factors used for all pollutants except for VOC are the weighted averages of emission factors for commercial diesel motorships and steamships. Reactive VOC is determined to be a percentage of total VOC as taken from Profile 9-07-021 of the VOC Species Data Manual.[40] Each emission factor is derived in a series of calculations using emission factor data presented in AP-42, Tables II-3-1, II-3-2 and II-3-4.[8] For the purposes of these calculations the following assumptions are made:

1. Commercial vessel population is comprised of 75 percent motorships and 25 percent steamships.

2. Commercial steamships spend 80 percent of the time hotelling and 20 percent underway.

3. Diesel steamships spend 20 percent of the time under auxiliary power and 80 percent underway.

Efforts are made to exclude operations conducted outside the Continental U.S.

Residual Oil Vessels

Emissions are estimated for marine vessels which use residual oil. This category includes large cargo and passenger ships, oil tankers, tugboats, and all other steamships and motorships that are known to consume residual oil. The activity level, measured in thousands of gallons, is multiplied by emission factors to obtain emissions estimates.

The original methodology estimated county level residual oil consumption based on 1975 data concerning the number, type, and size of ship, and time spent in port and underway. Consumption by vessels at ports for which consumption data were available was assigned to the port county. The remaining fuel consumption was distributed to ports and waterways according to tonnage handled. The original methodology was based on fuel sales to vessels from Fuel Oil and Kerosene Sales[12], and ship characteristics from Waterborne Commerce of the United States.[49]

The methodology currently used to determine the consumption of residual oil by marine vessels requires the updating of the most recent year's estimate with fuel data obtained from "Fuel Use by Vessels Bunkering" in the Fuel Oil and Kerosene Sales report[12] excluding fuel used by ships outside the U.S. continental limits.

Residual Oil Vessel Equations --

County consumption of residual fuel by marine vessels (MVR) (1000 gallons) is computed using the formula:

$$MVR = PIPR \cdot \frac{CMVR}{\sum_{n=1}^{c} CMVR_n} \cdot SMR$$

where:

MVR	=	County consumption of residual fuel by marine vessels
PIPR	=	Percent of residual fuel consumed within the Continental U.S.
CMVR	=	County consumption of residual fuel by marine vessels on AIRS AMS statistical file
SMR	=	State deliveries of residual fuel for use by marine vessels
c	=	Number of counties in State

Residual Oil Vessel Emission Factors --

Emission factors used for all pollutants except for VOC are the weighted average of the emission factors for commercial residual oil motorships and steamships. Reactive VOC is determined as a percentage of the total VOC as taken from Profile 1-01-004 of the VOC Species Data Manual.[40] Each emission factor is determined with AP-42, Tables II-3-1 and II-3-2[8] by the same procedure as in Distillate Oil Vessels using assumptions 1 and 2.

Gasoline Vessels

County marine consumption of gasoline is calculated using an algorithm that accounts separately for inboard and outboard motor use.[11,35] Using this method, State gasoline consumption figures are derived from State boat registration (inboard and outboard), and average fuel consumption for each boat type (gallons per hour). State consumption is then allocated to counties according to county inland water area, coastline, and the number of warm months which are suitable for recreational boating activities. The number of warm months is assumed to be the number of months during which the monthly normal temperatures exceed 45°F for counties north of 43° latitude, 48°F for counties between 37° and 43° latitude, and 55°F for counties south of 37° latitude. Coastline is converted to inland water area using a factor which is the ratio of coastline and open water boating density to inland water area and inland boating density.

Boat registration data are obtained from National Marine Manufacturing Association's Boating Registration Statistics.[50] Average fuel consumption for inboard and outboard motors is assumed to be 3.0 and 1.5 gallons per hour, respectively. County inland water and coastline areas are available in Bureau of Census Area Measurement Report: U.S. Summary.[51] Weather data are found in NOAA's Climatological Data.[6]

Gasoline Vessel Equations --

A normalized estimate of gasoline consumption by Marine Vessels (NMVG) (1000 gallons) is computed using the formula:

$$NMVG = MVG \cdot \frac{SMVG}{\sum_{n=1}^{c} MVG_n}$$

where: NMVG = Normalized estimate of gasoline consumption by marine vessels
MVG = Estimate of county gasoline consumption by marine vessels (computed below)
SMVG = Reported State consumption of gasoline use by marine vessels
c = Number of counties in State

The formula used to compute (MVG) is:

$$MVG = \frac{CIW + (f_s \cdot CC)}{SIW + (f_s \cdot SC)} \cdot \frac{10 \cdot CWM \cdot (SIB \cdot IFC + SOB \cdot OFC)}{1000}$$

where: CIW = County inland water area
f_s = State factor for converting coastline to inland water area
CC = County coastline
SIW = State inland water area
SC = State coastline
CWM = Number of "warm" months in county
SIB = State inboard boat population
IFC = Average gasoline consumption rate (gallons/hour) of inboard boats
SOB = State outboard boat population
OFC = Average gasoline consumption rate (gallons/hour) of outboard boats

Gasoline Vessel Emission Factors --

Average weighted emission factors are based on the inboard and outboard motorboat registrations. Weighting accounts for higher fuel consumption per hour operation by inboard motors. For VOC, it is assumed that the reactive fraction is 0.9172 based on VOC Species Data Manual, Profile 9-06-021B.[40]

RAILROAD LOCOMOTIVES

This category includes fuel utilized by railroad locomotives and fuel used by railroad stations and workshops for space heating. The latter fuel consumption has been included primarily because it is difficult to separate from total railroad fuel use and is considered insignificant compared to locomotive

consumption. The primary fuel consumed by railroad locomotives is distillate oil (diesel fuel). The activity level, measured in thousands of gallons, is multiplied by emission factors to produce emissions estimates.

The methodology used to estimate distillate oil consumption involves the allocation of published State consumption of distillate oil by railroad locomotives to the county level on the basis of current population distribution.

Data on the use of distillate oil by railroads for each State are obtained from DOE's Fuel Oil and Kerosene Sales report.[12] Population statistics are available from the Current Population Reports.[15]

Railroad Locomotive Equation

County consumption of diesel fuel by railroads (RRD) (1000 gallons) is computed using the formula:

$$RRD = SRD \cdot \frac{CP}{SP}$$

where: RRD = County consumption of diesel fuel by railroads
SRD = State fuel oil deliveries to railroads
CP = Current county population
SP = Current State population

Railroad Locomotive Emission Factors

The emission factors for railroad use are taken from AP- 42, Table II-2-2.[8]

GASOLINE MARKETING

This source category covers evaporative losses of volatile organic compounds from gasoline marketing operations such as filling losses from loading underground storage tanks at service stations, and spillage and filling losses from filling automobile tanks. Gasoline evaporative losses at refineries or bulk distribution terminals are not included. Emissions from refineries are assumed to be accounted for in point source categories.

The activity level for this category, measured by retail gas sales in thousands of gallons, is multiplied by emission factors to generate emissions.

Retail sales of gasoline include all sales of gasoline for highway use, aviation use, and for use by the construction equipment, industrial equipment, and farm equipment off-highway subcategories. Sales to the above user categories are estimated separately and summed to generate total county sales.

State retail sales of gasoline for highway and marine use are allocated to each county according to the county's proportion of the Statewide gross dollar receipts from gasoline service stations. Published State aviation retail sales of gasoline are allocated to the county according to the total LTO cycles in the county for each of the military, civilian, and commercial aircraft categories.

County retail sales of gasoline for off-highway sources are assumed to be the same as consumption derived in the activity levels section of Farm Equipment, Construction Equipment, and Industrial Equipment in Off-highway sources.[11]

Retail sales of gasoline for each category are obtained from the Census Bureau's quinquennial Census of Retail Trade.[52]

Retail Gasoline Sales: Gasoline Marketing - Stage I, Stage II, and Spillage Equations

A county estimate of Retail Gasoline Sales (CGS) (1000 gallons) is computed using the formula:

$$CGS = SHG \cdot \frac{CGR}{SGR} + NCFG + CGCE + CGIC + SAG \cdot \frac{CLT}{SLT}$$

where:	CGS	=	County estimate of retail gasoline sales
	SHG	=	State retail sales of gasoline for highway and marine use (computed below)
	CGR	=	Gross receipts of gasoline service stations in county
	SGR	=	Gross receipts of gasoline service stations in State
	NCFG	=	Normalized estimate of county gasoline consumption by farm equipment (See Off-Highway Gasoline: Farm Equipment Equations)
	CGCE	=	Estimate of county gasoline consumption by construction equipment (See Off-Highway Gasoline: Construction Equipment Equations)
	CGIC	=	Estimate of county gasoline consumption by industrial and commercial equipment (See Off-Highway Gasoline: Industrial and Commercial Equipment Equations)
	SAG	=	State aviation gasoline consumption
	CLT	=	Total LTO cycles in county for military, civil, and commercial aircraft (see Aircraft Category Calculations)
	SLT	=	Total LTO cycles in State for aircraft categories

The formula used to compute (CLT) is:

$$CLT = LTO_{AC} + LTO_{AT} + LTO_{M} + LTO_{CR}$$

The formula used to compute (SLT) is:

$$SLT = \sum_{n=1}^{c} CLT_n$$

where: c = number of counties in the State

The formula used to compute (SHG) is:

$$SHG = TSO + TSH - SGC + SGI + SGF + SAG$$

where:	TSO	=	Reported total State off-highway consumption
	TSH	=	Reported total State highway gasoline consumption
	SGC	=	Reported State gasoline consumption by construction equipment
	SGI	=	Reported State industrial/commercial gasoline consumption
	SGF	=	Reported State agricultural gasoline consumption
	SAG	=	Reported State aviation gasoline consumption

Retail Gasoline Sales: Gasoline Marketing - Stage I, Stage II, and Spillage Emission Factors

Emission factors are obtained from AP-42, Table 4.4-7.[8]

UNPAVED ROADS

Vehicle traffic over unpaved roads, parking areas, and recreational areas generates fugitive dust emissions which are estimated in AMS. Primary factors which affect the amount of dust generated are vehicle speed, surface type, wind speed, surface moisture, and type of vehicle. Methodologies for the estimation of activity level measured in VMT and for emission factor derivation are described below.

The methodology to determine county VMT on unpaved roads is based on regression analysis of data collected for VMT per county and mileage of unpaved roads per county. County road mileages for this study were obtained from State transportation or highway departments. VMT was found to be dependent on the county population and mileage of unpaved roads in the county.

County population statistics are taken from Current Population Reports.[15] State road mileage for surface types A through E are published annually by FHWA's Highway Statistics.[31]

Unpaved Roads: VMT Equations

County estimates of unpaved road VMT (UPR) are computed using the following equation:

$$UPR = CUPR \cdot \frac{CUPM}{SUPM}$$

where:	UPR	=	County estimate of unpaved road VMT
	CUPR	=	County estimate of unpaved road VMT on AIRS AMS statistical file
	CUPM	=	Reported unpaved road miles by State in current year
	SUPM	=	Reported unpaved road miles by State in previous year

If CUPM is not available, then the following equation is used:

$$UPR = CUPR \cdot \frac{CRUPM}{RUPM}$$

where: CRUPM = Reported unpaved road miles by Census Region in current year
RUPM = Reported unpaved road miles by Census Region in previous year

If CRUPM is not available, then the following equation is used:

$$UPR = CUPR \cdot \frac{CNUPM}{NUPM}$$

where: CNUPM = Reported unpaved road miles for the nation in current year
NUPM = Reported unpaved road miles for the nation in previous year

Unpaved Roads: VMT Emission Factors

Emission factors are computed using the equation in AP-42, section 11.2.1.[8] The aerodynamic particle size multiplier corresponding to the inclusion of particles less than or equal to 30 micrometers was used. Average vehicle speed is assumed to be 40 miles per hour. Road surface material, silt content, and the number of days with precipitation are taken from Emissions Inventory of Agricultural Tilling, Unpaved Roads and Airstrips, and Construction Sites.[48] Mean vehicle weight for four-wheeled vehicles is assumed to be 3.69 tons.

SECTION 5

INDUSTRIAL PROCESSES

Industrial processes are very properly considered as point sources in most emission inventories and in the recent past have not been considered to be significant contributors to area source emissions. However, there may be many industrial processes that are too small to be considered point sources, but collectively may contribute substantially to the overall total. At the present time, no methodologies are available to estimate activity levels on a county basis.

CONSTRUCTION

Road and building construction activities generate particulate emissions. Principal activities in construction which cause dust emissions are land clearing, excavation, and vehicle traffic around the construction site. Variables known to affect emissions are soil type, moisture, wind speed, and type of on-site operations. At present, no methodology is available to estimate activity level at the county level. However, emission factors are available from AP-42 (Section 11.2.4).[8]

SECTION 6

SOLVENT UTILIZATION

The following discussion documents the estimation procedures for evaporative losses of VOC from solvent usage by area sources. Organic solvent usage is divided into seven major categories: surface coating operations, degreasing, dry cleaning, graphic arts, rubber and plastic manufacturing, miscellaneous industrial operations, and miscellaneous nonindustrial operations. Surface coating is further divided into the following subcategories: architectural coatings, auto refinishing, textile products, flatwood products, wood furniture, metal furniture, paper, plastic products, cans, metal coils, miscellaneous finished metals, electrical, large appliances, magnet wire, motor vehicles, aircraft, marine, railroad, and miscellaneous manufacturing operations. In each category, usage of specific solvents is identified and enumerated to compute total solvent usage in short tons per year.

The methodology for allocating organic solvent consumption by county consists of apportioning national consumption of 20 primary solvent groups by major user category according to county population or employment data.[3] User categories are listed in Table 1. Table 2 contains a list of the primary solvent groups used to determine losses from organic solvent consumption. The category "special naphthas" includes the aliphatic naphthas such as varnish makers' and painters' (VMP) naphthas, Stoddard solvent, rubber solvents, and mineral spirits.

In the algorithm, national consumption of the primary solvent groups is distributed to each of the user categories according to the percentage of total solvent consumption used by the user category.[3] Percentage usage obtained from published sources is compiled for each user category shown in Table 3. National area source solvent use estimates are determined by subtracting point source solvent use or emissions for each user category from total solvent use for each user category.

County consumption for each solvent and user category is then computed by allocating calculated national area source consumption on the basis of applicable county SIC area source employment or population, as shown in Table 1. For example, in the degreasing processes user category, total solvent use is allocated to each county in proportion to the county area source employment for SICs 34 through 39. Area source employment is determined by subtracting point source employment from total county employment for each SIC category. For dry cleaning applications, the county wide allocation is made on the basis of total employment in SICs 7215, 7216, and 7218. To reflect the unequal solvent use in particular establishments within SIC groups, consumption is multiplied by a factor, which compares the number of individuals in the county in each area source user category to the number of individuals in the nation in each area source user category. County consumption of each solvent type is then summed for each county to yield a total county consumption.

The reported national consumption of each solvent is extracted from DOE Petroleum Supply Annual[24] and ITC's Synthetic Organic Chemicals.[27] The percentage of each solvent consumed by each solvent user category is obtained from Chemical Products Synopsis[53] and Chemical Profiles.[54] Total employment is obtained from County Business Patterns.[22] Point source employment is estimated using plant data from the AIRS/FS[20] and employment data from County Business Patterns.[22] Solvent consumption amounts used for surface coating are taken from the annual "Trends" report.[55] County population is obtained from Current Population Reports.[15]

TABLE 1: USER CATEGORIES

User Categories	Population or Employment Data by SIC Used for County Allocation
Surface Coating	
Architectural Coatings (AC)	County Population
Auto Refinishing (AR)	SIC 7535
Textile Products (TP)	SIC 22
Flatwood Products (FP)	SIC 243 + 244
Wood Furniture (WF)	SIC 25 partial
Metal Furniture (MF)	SIC 25 partial
Paper (PA)	SIC 26
Plastic Products (PP)	SIC 308
Cans (CN)	SIC 341
Metal Coils (MC)	SIC 3498
Misc. Finished Metals (MM)	SIC 34-(341+3498)
Electrical (EC)	SIC 35
Large Appliances (LA)	SIC 363
Magnet Wire (MW)	SIC 36 - 363
Motor Vehicles (MV)	SIC 371
Aircraft (AI)	SIC 372
Marine (MA)	SIC 373
Railroad (RR)	SIC 374
Miscellaneous Manufacturing (MS)	Total Mfg. - Above SIC employment
Degreasing (DG)	SIC 34 - 39
Dry Cleaning (DC)	SIC (7216 x 2) + 7215 + 7218
Graphic Arts (GA)	SIC 264 + 265 + 27
Rubber & Plastics (RP)	SIC 30
Miscellaneous Industrial (MI)	SIC 20 - 39
Miscellaneous NonIndustrial (MN)	County Population

TABLE 2: ORGANIC SOLVENTS

1.	Special Naphthas	11.	Propylene Glycol
2.	Perchloroethylene	12.	Methanol
3.	Ethanol	13.	Butyl Acetate
4.	Trichloroethylene	14.	Ethyl Acetate
5.	Isopropanol	15.	Butyl Alcohols
6.	Acetone	16.	Methyl Isobutyl Ketone
7.	Glycol Ethers	17.	Monochlorobenzene
8.	Cyclohexanone	18.	o-Dichlorobenzene
9.	Methyl Ethyl Ketone	19.	p-Dichlorobenzene
10.	Ethyl Benzene	20.	All Other Solvents*

TABLE 3: PERCENTAGE END USE OF SOLVENTS BY MAJOR SOLVENT CATEGORY

Solvent Type	Surface Coating	Degreasing	Dry Cleaning	Graphic Arts	Rubber & Plastics	Miscellaneous Industrial	Miscellaneous Non-Industrial
Special Naphthas	48.7	6.7	2.0	6.4	9.6	7.1	10.7
Perchloroethylene		10.0	53.0				4.0
Ethanol						26.0	
Trichloroethylene		80.0					5.0
Isopropanol	15.0					9.0	37.0
Acetone	17.0						11.5
Glycol Ethers	43.0					10.0	
Cyclohexanone						5.0	
Methyl Ethyl Ketone	69.4					10.0	
Ethyl Benzene							0.5
Propylene Glycol						4.0	6.0
Methanol					54.0	8.0	15.0
Butyl Acetate	65.0			5.0			3.0
Ethyl Acetate	41.0				8.0		13.0
Butyl Alcohols	15.5					1.8	1.3
Methyl Isobutyl Ketone	65.5					8.0	18.0
Monochlorobenzene		21.0				21.0	11.0
o-Dichlorobenzene						25.0	5.0
p-Dichlorobenzene					23.0		46.0
All Other Solvents							

* *All Other Solvents* (AOS) is calculated in the following manner:

$$AOS = 0.0018\ (NTSC_{SC} + NTSC_{GA} + NTSC_{MI} + NTSC_{MN})$$

where: AOS = All other solvents
$NTSC_{SC}$ = National solvent consumption due to surface coating (computed below)
$NTSC_{GA}$ = National solvent consumption due to graphic arts (computed below)
$NTSC_{MI}$ = National solvent consumption due to miscellaneous industrial applications (computed below)
$NTSC_{MN}$ = National solvent consumption due to miscellaneous nonindustrial applications (computed below)

$NTSC_{SC}$ is computed as follows:

$$NTSC_{SC} = \sum_{s=1}^{20} \left(\frac{CST_s \cdot NSP_{SC,s}}{2000} \right)$$

where: CST_s = Published solvent consumption for the nation for each of 20 different solvent types (pounds)
$NSP_{SC,s}$ = National percent of solvent due to surface coating for each of 20 solvent types

$NTSC_{GA}$ is computed as follows:

$$NTSC_{GA} = \sum_{s=1}^{20} \left(\frac{CST_s \cdot NSP_{GA,s}}{2000} \right)$$

where: CST_s = Published solvent consumption for the nation for each of 20 different solvent types (pounds)
$NSP_{GA,s}$ = National percent of solvent due to the graphic arts trades for each of 20 solvent types

$NTSC_{MI}$ is computed as follows:

$$NTSC_{MI} = \sum_{s=1}^{20} \left(\frac{CST_s \cdot NSP_{MI,s}}{2000} \right)$$

where: CST_s = Published solvent consumption for the nation for each of 20 different solvent types (pounds)

$NSP_{MI,s}$ = National percent of solvent due to the miscellaneous industrial trades for each of 20 solvent types

$NTSC_{MN}$ is computed as follows:

$$NTSC_{MN} = \sum_{s=1}^{20} \left(\frac{CST_s \cdot NSP_{MN,s}}{2000} \right)$$

where: CST_s = Published solvent consumption for the nation for each of 20 different solvent types (pounds)

$NSP_{MN,s}$ = National percent of solvent due to the miscellaneous nonindustrial trades for each of 20 solvent types

The term 's', used throughout Section 6, indicates the list of primary solvent groups used to determine losses from organic solvent consumption. The category "special naphthas" includes the aliphatic naphthas such as VMP naphthas, Stoddard solvent, rubber solvents, and mineral spirits.

where: s = Solvents listed in Table 2

SURFACE COATING

An estimate of County Organic Solvent Consumption for Surface Coating at each of 19 different user categories (COS_{uc}) (in short tons) is computed as follows:

$$COS_{uc} = \sum_{s=1}^{20} \left(\frac{CE_{uc} - CPE_{uc}}{NE_{uc} - NPE_{uc}} \cdot NOS_{uc,s} \right)$$

where: COS_{uc} = Estimated county organic solvent consumption for surface coating - architectural uses

uc = 1 for Architectural Coating (County Population)
2 for Auto Refinishing (SIC 7535)
3 for Textile Products (SIC 22)
4 for Flatwood Products (SIC 243 + 244)
5 for Wood Furniture (SIC 25 partial)
6 for Metal Furniture (SIC 25 partial)
7 for Paper (SIC 26)
8 for Plastic Products (SIC 308)
9 for Cans (SIC 341)
10 for Metal Coils (SIC 3498)
11 for Miscellaneous Finished Metals (SIC 34 except 341 & 3498)
12 for Electrical (SIC 35)
13 for Large Appliances (SIC 363)
14 for Magnet Wire (SIC 36 - 363)
15 for Motor Vehicles (SIC 371)
16 for Aircraft (SIC 372)
17 for Marine (SIC 373)
18 for Railroad (SIC 374)
19 for Miscellaneous Manufacturing (Total Mfg. - Above SIC employment)

CE_{uc} = Total current county area source employment or population for a given surface coating user category

CPE_{uc} = Total point source county employment for a given surface coating user category

NE_{uc} = Total national employment or population for a given surface coating user category

NPE_{uc} = Total point source employment for a given surface coating user category

$NOS_{uc,s}$ = National organic solvent consumption for 20 different solvent types for use in architectural coatings (computed below)

NOTE: For the architectural surface coating category, the terms "CPE" and "NPE" equal zero.

$NOS_{uc,s}$ is computed as follows:

$$NOS_{uc,s} = \frac{CST_s \cdot PSU_{uc,s}}{2000}$$

where: CST_s = Published total of national consumption of solvent type s (pounds)

$PSU_{uc,s}$ = Percent of solvent type s that is consumed by architectural uses at area sources (computed below)

$PSU_{uc,s}$ is computed as follows:

$$PSU_{uc,s} = \left[\frac{TR_{uc} - \left(TR_{uc} \cdot \frac{NPE_{uc}}{NE_{uc}} \right)}{\sum_{uc=3}^{17} TR_{uc} - \left(TR_{uc} \cdot \frac{NPE_{uc}}{NE_{uc}} \right)} \right] \cdot \frac{ASCU_{sc}}{TUSC_{sc}} \cdot PSCA_{sc,s}$$

where: TR_{uc} = Reference 55 -- amount of solvent consumption due to a given *surface coating user category* (uc)

NPE_{uc} = National point source employment in a given SIC group

NE_{uc} = National employment in a given SIC group

uc = 3 for Textile Products (SIC 22)
4 for Flatwood Products (SIC 243 + 244)
5 for Wood Furniture (SIC 25 partial)
6 for Metal Furniture (SIC 25 partial)
7 for Paper (SIC 26)
8 for Plastic Products (SIC 308)
9 for Cans (SIC 341)
10 for Metal Coils (SIC 3498)
11 for Miscellaneous Finished Metals (SIC 34 except 341 & 3498)
12 for Electrical (SIC 35)
13 for Large Appliances (SIC 363)
14 for Magnet Wire (SIC 36 - 363)
15 for Motor Vehicles (SIC 371)
16 for Aircraft (SIC 372)
17 for Marine (SIC 373)
18 for Railroad (SIC 374)
19 for Miscellaneous Manufacturing (Total Mfg. - Above SIC employment)

$ASCU_{sc}$ = Area source solvent consumption at surface coating operations - uncontrolled (computed below)

$TUSC_{sc}$ = Total area source solvent consumption due to surface coating operations at area sources - uncontrolled (computed below)

$PSCA_{sc,s}$ = Percentage of solvent consumption at area sources due to

surface coatings (SC) for 20 solvent types (computed below)

NOTE: $PSU_{uc,s}$ is computed differently for architectural coatings and auto refinishing. The equations to compute PSU for these two surface coating categories are as follows:

Architectural Coatings: PSU

$$PSU_{uc,s} = \frac{TRAC}{TUSC_{sc}} \cdot PSCA_{sc,s}$$

where: TRAC = Reference 55 -- amount of solvent consumption due to architectural coating

$TUSC_{sc}$ = Total area source solvent consumption due to surface coating operations at area sources - uncontrolled (computed below)

$PSCA_{sc,s}$ = Percentage of solvent consumption at area sources due to surface coatings (SC) for 20 solvent types (computed below)

Auto Refinishing: PSU

$$PSU_{uc,s} = \frac{TRAR}{TUSC_{sc}} \cdot PSCA_{sc,s}$$

where: TRAR = Reference 55 -- amount of solvent consumption due to auto refinishing

$TUSC_{sc}$ = Total area source solvent consumption due to surface coating operations at area sources - uncontrolled (computed below)

$PSCA_{sc,s}$ = Percentage of solvent consumption at area sources due to surface coatings (SC) for 20 solvent types (computed below)

$TUSC_{sc}$ is computed as follows:

$$TUSC_{sc} = ASCU_{sc} + TRAC + TRAR$$

where: $ASCU_{sc}$ = Area source solvent consumption at surface coating operations - uncontrolled (computed below)

TRAC = Reference 55 -- amount of solvent consumption due to architectural coating

TRAR = Reference 55 -- amount of solvent consumption due to auto refinishing

$PSCA_{SC,s}$ is computed as follows:

$$PSCA_{SC,s} = \frac{TSC_{SC}}{NTSC_{SC}} \cdot NSP_{SC,s}$$

where: TSC_{SC} = Total area source solvent consumption due to surface coating - controlled (computed below)

$NTSC_{SC}$ = National solvent consumption due to surface coating (computed below)

$NSP_{SC,s}$ = National percent of solvent due to surface coating for each of 20 solvent types

TSC_{SC} is computed as follows:

$$TSC_{SC} = \left[ASCU_{SC} \cdot \left(\frac{100 - SCC_{SC}}{100}\right)\right] + TRAC + TRAR$$

where: $ASCU_{SC}$ = Area source solvent consumption due to surface coating - uncontrolled (computed below)

SCC_{SC} = Percent of control at surface coating operations at area sources

$ASCU_{SC}$ is computed as follows:

$$ASCU_{SC} = [NTSC_{SC} - (TRAC + TRAR)] - \left[\frac{PTSC_{SC}}{\left(\frac{100 - PTSCC_{SC}}{100}\right)}\right]$$

where: $PTSC_{SC}$ = Point source solvent consumption/emissions from surface coating - actual (Reference 20)

$PTSCC_{SC}$ = Percent of control at surface coating operations at point sources

$NTSC_{SC}$ is computed as follows:

$$NTSC_{SC} = \sum_{s=1}^{20} \left(\frac{CST_s \cdot NSP_{SC,s}}{2000}\right)$$

where: CST_s = Published solvent consumption for the nation for each of 20 different solvent types (pounds)

$NSP_{SC,s}$ = National percent of solvent due to surface coating for each of 20 solvent types

DEGREASING (SIC 34 through 39)

An estimate of County Organic Solvent Consumption for Degreasing (COS_{DG}) (in short tons) is computed as follows:

$$COS_{DG} = \sum_{s=1}^{20} \left(\frac{CE_{DG} - CPE_{DG}}{NE_{DG} - NPE_{DG}} \cdot NOS_{DG,s} \right)$$

where:
- COS_{DG} = Estimated county organic solvent consumption for degreasing
- CE_{DG} = Current county employment in the degreasing trades -- SICs 34 through 39
- CPE_{DG} = Current county point source employment in the degreasing trades -- SICs 34 through 39
- NE_{DG} = Current national employment in the degreasing trades -- SICs 34 through 39
- NPE_{DG} = Current national point source employment in the degreasing trades -- SICs 34 through 39
- $NOS_{DG,s}$ = National organic solvent consumption by the degreasing trades (computed below)

$NOS_{DG,s}$ is computed as follows:

$$NOS_{DG,s} = \frac{CST_s \cdot PSU_{DG,s}}{2000}$$

where:
- CST_s = Published total of national consumption of solvent type s (pounds)
- $PSU_{DG,s}$ = Percent of solvent type s that is consumed by the degreasing trades at area sources (computed below)

$PSU_{DG,s}$ is computed as follows:

$$PSU_{DG,s} = PSCA_{DG,s}$$

where:
- $PSCA_{DG,s}$ = Percent solvent consumption at area sources due to the degreasing trade for 20 solvent types (computed below)

$PSCA_{DG,s}$ is computed as follows:

$$PSCA_{DG,s} = \frac{TSC_{DG}}{NTSC_{DG}} \cdot NSP_{DG,s}$$

where: TSC_{DG} = Total area source solvent consumption due to the degreasing trades - controlled (computed below)

$NTSC_{DG}$ = National solvent consumption due to the degreasing trades (computed below)

$NSP_{DG,s}$ = National percent of solvent due to the degreasing trade for each of 20 solvent types

TSC_{DG} is computed as follows:

$$TSC_{DG} = ASCU_{DG} \cdot \left(\frac{100 - SCC_{DG}}{100} \right)$$

where: $ASCU_{DG}$ = Area source solvent consumption due to the degreasing trades - uncontrolled (computed below)

SCC_{DG} = Percent of control at degreasing trades at area sources

$ASCU_{DG}$ is computed as follows:

$$ASCU_{DG} = NTSC_{DG} - \left[\frac{PTSC_{DG}}{\left(\frac{100 - PTSCC_{DG}}{100} \right)} \right]$$

where: $PTSC_{DG}$ = Point source solvent consumption/emissions from degreasing operations - actual (Reference 20)

$PTSCC_{DG}$ = Percent of control at degreasing operations at point sources

$NTSC_{DG}$ is computed as follows:

$$NTSC_{DG} = \sum_{s=1}^{20} \left(\frac{CST_s \cdot NSP_{DG,s}}{2000} \right)$$

where: CST_s = Published solvent consumption for the nation for each of 20 different solvent types (pounds)

$NSP_{DG,s}$ = National percent of solvent due to the degreasing trades for each of 20 solvent types

DRY CLEANING (SIC 7215, 7216 and 7218)

An estimate of County Organic Solvent Consumption for Dry Cleaning (COS_{DC}) (in short tons) is computed as follows:

$$COS_{DC} = \sum_{s=1}^{20} \left(\frac{CE_{DC} - CPE_{DC}}{NE_{DC} - NPE_{DC}} \cdot NOS_{DC,s} \right)$$

where: COS_{DC} = Estimated county organic solvent consumption for dry cleaning
CE_{DC} = Current county employment in the dry cleaning trades -- SICs 7215 + 7218 + (2 * 7216)
CPE_{DC} = Current county point source employment in the dry cleaning trades -- SICs 7215 + 7218 + (2 * 7216)
NE_{DC} = Current national employment in the dry cleaning trades -- SICs 7215 + 7218 + (2 * 7216)
NPE_{DC} = Current national point source employment in the dry cleaning trades -- SICs 7215 + 7218 + (2 * 7216)
$NOS_{DC,s}$ = National organic solvent consumption by the dry cleaning trades for 20 different solvent types (computed below)

$NOS_{DC,s}$ is computed as follows:

$$NOS_{DC,s} = \frac{CST_s \cdot PSU_{DC,s}}{2000}$$

where: CST_s = Published total of national consumption of solvent type s (pounds)
$PSU_{DC,s}$ = Percent of solvent type s that is consumed by the dry cleaning trade at area sources (computed below)

$PSU_{DC,s}$ is computed as follows:

$$PSU_{DC,s} = PSCA_{DC,s}$$

where: $PSCA_{DC,s}$ = Percent solvent consumption at area sources due to the dry cleaning trade for 20 solvent types (computed below)

$PSCA_{DC,s}$ is computed as follows:

$$PSCA_{DC,s} = \frac{TSC_{DC}}{NTSC_{DC}} \cdot NSP_{DC,s}$$

where: TSC_{DC} = Total area source solvent consumption due to the dry cleaning trades - controlled (computed below)

$NTSC_{DC}$ = National solvent consumption due to the dry cleaning trades (computed below)

$NSP_{DC,s}$ = National percent of solvent due to the dry cleaning trade for each of 20 solvent types

TSC_{DC} is computed as follows:

$$TSC_{DC} = ASCU_{DC} \cdot \left(\frac{100 - SCC_{DC}}{100} \right)$$

where: $ASCU_{DC}$ = Area source solvent consumption due to the dry cleaning trades - uncontrolled (computed below)

SCC_{DC} = Percent of control at dry cleaning trades at area sources

$ASCU_{DC}$ is computed as follows:

$$ASCU_{DC} = NTSC_{DC} - \left[\frac{PTSC_{DC}}{\left(\frac{100 - PTSCC_{DC}}{100} \right)} \right]$$

where: $PTSC_{DC}$ = Point source solvent consumption/emissions from dry cleaning operations - actual (Reference 20)

$PTSCC_{DC}$ = Percent of control at dry cleaning operations at point sources

$NTSC_{DC}$ is computed as follows:

$$NTSC_{DC} = \sum_{s=1}^{20} \left(\frac{CST_s \cdot NSP_{DC,s}}{2000} \right)$$

where: CST = Published solvent consumption for the nation for each of 20 different solvent types (pounds)

NSP_{DC} = National percent of solvent due to the dry cleaning trades for each of 20 solvent types

GRAPHIC ARTS (SIC 264, 265, and 27)

An estimate of County Organic Solvent Consumption for Graphic Arts (COS_{GA}) (in short tons) is computed as follows:

$$COS_{GA} = \sum_{s=1}^{20} \left(\frac{CE_{GA} - CPE_{GA}}{NE_{GA} - NPE_{GA}} \cdot NOS_{GA,s} \right)$$

where: COS_{GA} = Estimated county organic solvent consumption for graphic arts

CE_{GA} = Current county employment in the graphic arts trades -- SICs 264 + 265 + 27

CPE_{GA} = Current county point source employment in the graphic arts trades -- SICs 264 + 265 + 27

NE_{GA} = Current national employment in the graphic arts trades -- SICs 264 + 265 + 27

NPE_{GA} = Current national point source employment in the graphic arts trades -- SICs 264 + 265 + 27

$NOS_{GA,s}$ = National organic solvent consumption by the graphic arts trades for 20 different solvent types (computed below)

$NOS_{GA,s}$ is computed as follows:

$$NOS_{GA,s} = \frac{CST_s \cdot PSU_{GA,s}}{2000}$$

where: CST_s = Published total of national consumption of solvent type s (pounds)

$PSU_{GA,s}$ = Percent of solvent type s that is consumed by the graphic arts trades at area sources (computed below)

$PSU_{GA,s}$ is computed as follows:

$$PSU_{GA,s} = PSCA_{GA,s}$$

where: $PSCA_{GA,s}$ = Percent solvent consumption at area sources due to the graphic arts trades for 20 solvent types (computed below)

$PSCA_{GA,s}$ is computed as follows:

$$PSCA_{GA,s} = \frac{TSC_{GA}}{NTSC_{GA}} \cdot NSP_{GA,s}$$

where: TSC_{GA} = Total area source solvent consumption due to the graphic arts trades - controlled (computed below)

$NTSC_{GA}$ = National solvent consumption due to the graphic arts trades (computed below)

$NSP_{GA,s}$ = National percent of solvent due to the graphic arts trades for each of 20 solvent types

TSC_{GA} is computed as follows:

$$TSC_{GA} = ASCU_{GA} \cdot \left(\frac{100 - SCC_{GA}}{100} \right)$$

where: $ASCU_{GA}$ = Area source solvent consumption due to the graphic arts trades - uncontrolled (computed below)

SCC_{GA} = Percent of control at graphic arts trades at area sources

$ASCU_{GA}$ is computed as follows:

$$ASCU_{GA} = NTSC_{GA} - \left[\frac{PTSC_{GA}}{\left(\frac{100 - PTSCC_{GA}}{100} \right)} \right]$$

where: $PTSC_{GA}$ = Point source solvent consumption/emissions from graphic arts operations - actual (Reference 20)

$PTSCC_{GA}$ = Percent of control at graphic arts operations at point sources

$NTSC_{GA}$ is computed as follows:

$$NTSC_{GA} = \sum_{s=1}^{20} \left(\frac{CST_s \cdot NSP_{GA,s}}{2000} \right)$$

where: CST_s = Published solvent consumption for the nation for each of 20 different solvent types (pounds)

$NSP_{GA,s}$ = National percent of solvent due to the graphic arts trades for each of 20 solvent types

RUBBER/PLASTICS (SIC 30)

An estimate of County Organic Solvent Consumption for Rubber/Plastics (COS_{RP}) (in short tons) is computed as follows:

$$COS_{RP} = \sum_{s=1}^{20} \left(\frac{CE_{RP} - CPE_{RP}}{NE_{RP} - NPE_{RP}} \cdot NOS_{RP,s} \right)$$

where: COS_{RP} = Estimated county organic solvent consumption for rubber/plastics

CE_{RP} = Current county employment in the rubber/plastics trades -- SIC 30

CPE_{RP} = Current county point source employment in the rubber/plastics trades -- SIC 30

NE_{RP} = Current national employment in the rubber/plastics trades -- SIC 30

NPE_{RP} = Current national point source employment in the rubber/plastics trades -- SIC 30

$NOS_{RP,s}$ = National organic solvent consumption by the rubber/plastics trades for 20 different solvent types (computed below)

$NOS_{RP,s}$ is computed as follows:

$$NOS_{RP,s} = \frac{CST_s \cdot PSU_{RP,s}}{2000}$$

where: CST_s = Published total of national consumption of solvent type s (pounds)

$PSU_{RP,s}$ = Percent of solvent type s that is consumed by the rubber/plastics trades at area sources (computed below)

$PSU_{RP,s}$ is computed as follows:

$$PSU_{RP,s} = PSCA_{RP,s}$$

where: $PSCA_{RP,s}$ = Percentage of solvent consumption at area sources due to the rubber/plastics trades for 20 solvent types (computed below)

$PSCA_{RP,s}$ is computed as follows:

$$PSCA_{RP,s} = \frac{TSC_{RP}}{NTSC_{RP}} \cdot NSP_{RP,s}$$

where: TSC_{RP} = Total area source solvent consumption due to the rubber/plastics trades - controlled (computed below)

$NTSC_{RP}$ = National solvent consumption due to the rubber/plastics trades (computed below)

$NSP_{RP,s}$ = National percent of solvent due to the rubber/plastics trades for each of 20 solvent types

TSC_{RP} is computed as follows:

$$TSC_{RP} = ASCU_{RP} \cdot \left(\frac{100 - SCC_{RP}}{100}\right)$$

where: $ASCU_{RP}$ = Area source solvent consumption due to the rubber/plastics trades - uncontrolled (computed below)

SCC_{RP} = Percent of control at rubber/plastics trades at area sources

$ASCU_{RP}$ is computed as follows:

$$ASCU_{RP} = NTSC_{RP} - \left[\frac{PTSC_{RP}}{\left(\frac{100 - PTSCC_{RP}}{100}\right)}\right]$$

where: $PTSC_{RP}$ = Point source solvent consumption/emissions from rubber/plastics operations - actual (Reference 20)

$PTSCC_{RP}$ = Percent of control at rubber/plastics operations at point sources

$NTSC_{RP}$ is computed as follows:

$$NTSC_{RP} = \sum_{s=1}^{20} \left(\frac{CST_s \cdot NSP_{RP,s}}{2000}\right)$$

where: CST_s = Published solvent consumption for the nation for each of 20 different solvent types (pounds)

$NSP_{RP,s}$ = National percent of solvent due to the rubber/plastics trades for each of 20 solvent types

MISCELLANEOUS INDUSTRIAL (SIC 20-39)

An estimate of County Organic Solvent Consumption for Miscellaneous Industrial Trades (COS_{MI}) (in short tons) is computed as follows:

$$COS_{MI} = \sum_{s=1}^{20} \left(\frac{CE_{MI}}{NE_{MI}} \cdot NOS_{MI,s} \right)$$

where: COS_{MI} = Estimated county organic solvent consumption for miscellaneous industrial trades

CE_{MI} = Current county employment in the miscellaneous industrial trades -- SICs 20 through 39

NE_{MI} = Current national employment in the miscellaneous industrial trades -- SICs 20 through 39

$NOS_{MI,s}$ = National organic solvent consumption by the miscellaneous industrial trades for each of 20 solvent types (computed below)

$NOS_{MI,s}$ is computed as follows:

$$NOS_{MI,s} = \frac{CST_s \cdot PSU_{MI,s}}{2000}$$

where: CST_s = Published total of national consumption of solvent type s (pounds)

$PSU_{MI,s}$ = Percent of solvent type s that is consumed by the miscellaneous industrial trades at area sources (computed below)

$PSU_{MI,s}$ is computed as follows:

$$PSU_{MI,s} = PSCA_{MI,s}$$

where: $PSCA_{MI,s}$ = Percent solvent consumption at area sources due to the miscellaneous industrial trades for 20 solvent types (computed below)

$PSCA_{MI,s}$ is computed as follows:

$$PSCA_{MI,s} = \frac{TSC_{MI}}{NTSC_{MI}} \cdot NSP_{MI,s}$$

where: TSC_{MI} = Total area source solvent consumption due to the miscellaneous industrial trades - controlled (computed below)

$NTSC_{MI}$ = National solvent consumption due to the miscellaneous industrial trades (computed below)

$NSP_{MI,s}$ = National percent of solvent due to the miscellaneous industrial trades for each of 20 solvent types

TSC_{MI} is computed as follows:

$$TSC_{MI} = ASCU_{MI} \cdot \left(\frac{100 - SCC_{MI}}{100} \right)$$

where: $ASCU_{MI}$ = Area source solvent consumption due to the miscellaneous industrial trades - uncontrolled (computed below)

SCC_{MI} = Percent of control at miscellaneous industrial trades at area sources

$ASCU_{MI}$ is computed as follows:

$$ASCU_{MI} = NTSC_{MI} - \left[\frac{PTSC_{MI}}{\left(\frac{100 - PTSCC_{MI}}{100} \right)} \right]$$

where: $PTSC_{MI}$ = Point source solvent consumption/emissions from miscellaneous industrial operations - actual (Reference 20)

$PTSCC_{MI}$ = Percent of control at miscellaneous industrial operations at point sources

$NTSC_{MI}$ is computed as follows:

$$NTSC_{MI} = \sum_{s=1}^{20} \left(\frac{CST_s \cdot NSP_{MI,s}}{2000} \right)$$

where: CST_s = Published solvent consumption for the nation for each of 20 different solvent types (pounds)

$NSP_{MI,s}$ = National percent of solvent due to the miscellaneous industrial trades for each of 20 solvent types

MISCELLANEOUS NONINDUSTRIAL

An estimate of County Organic Solvent Consumption for Miscellaneous Nonindustrial Trades (COS_{MN}) (in short tons) is computed as follows:

$$COS_{MN} = \sum_{s=1}^{20} \left(\frac{CP_{MN}}{NP_{MN}} \cdot NOS_{MN,s} \right)$$

where: COS_{MN} = Estimated county organic solvent consumption for miscellaneous nonindustrial trades
CP_{MN} = Current county population
NP_{MN} = Current national population
$NOS_{MN,s}$ = National organic solvent consumption by the miscellaneous nonindustrial trades for each of 20 solvent types (computed below)

$NOS_{MN,s}$ is computed as follows:

$$NOS_{MN,s} = \frac{CST_s \cdot PSU_{MN,s}}{2000}$$

where: CST_s = Published total of national consumption of solvent type s (pounds)
$PSU_{MN,s}$ = Percent of solvent type s that is consumed by the miscellaneous nonindustrial trades at area sources (computed below)

$PSU_{MN,s}$ is computed as follows:

$$PSU_{MN,s} = PSCA_{MN,s}$$

where: $PSCA_{MN,s}$ = Percent solvent consumption at area sources due to the miscellaneous nonindustrial trades for 20 solvent types (computed below)

$PSCA_{MN,s}$ is computed as follows:

$$PSCA_{MN,s} = \frac{TSC_{MN}}{NTSC_{MN}} \cdot NSP_{MN,s}$$

where: TSC_{MN} = Total area source solvent consumption due to the miscellaneous nonindustrial trades - controlled (computed below)

$NTSC_{MN}$ = National solvent consumption due to the miscellaneous nonindustrial trades (computed below)

$NSP_{MN,s}$ = National percent of solvent due to the miscellaneous nonindustrial trades for each of 20 solvent types

TSC_{MN} is computed as follows:

$$TSC_{MN} = ASCU_{MN} \cdot \left(\frac{100 - SCC_{MN}}{100} \right)$$

where: $ASCU_{MN}$ = Area source solvent consumption due to the miscellaneous nonindustrial trades - uncontrolled (computed below)

SCC_{MN} = Percent of control at miscellaneous nonindustrial trades at area sources

$ASCU_{MN}$ is computed as follows:

$$ASCU_{MN} = NTSC_{MN} - \left[\frac{PTSC_{MN}}{\left(\frac{100 - PTSCC_{MN}}{100} \right)} \right]$$

where: $PTSC_{MN}$ = Point source solvent consumption/emissions from miscellaneous nonindustrial operations - actual (Reference 20)

$PTSCC_{MN}$ = Percent of control at miscellaneous nonindustrial operations at point sources

$NTSC_{MN}$ is computed as follows:

$$NTSC_{MN} = \sum_{s=1}^{20} \left(\frac{CST_s \cdot NSP_{MN,s}}{2000} \right)$$

where: CST_s = Published solvent consumption for the nation for each of 20 different solvent types (pounds)

$NSP_{MN,s}$ = National percent of solvent due to the miscellaneous nonindustrial trades for each of 20 solvent types

SOLVENT UTILIZATION EMISSION FACTORS

Emission factors for release of VOC assume complete evaporation of all organic solvents (2000 pounds per ton of solvent used).

SECTION 7

SOLID WASTE DISPOSAL

The area source category for solid waste disposal includes on-site refuse disposal activities by residential, commercial/institutional, and industrial sectors. In this section, emissions from the disposal practices of open burning and on-site incineration are discussed separately. Solid waste generation in short tons is used as a measure of activity level.

ON-SITE INCINERATION

For the purposes of determining the amount of solid waste generated, on-site incineration is defined as disposal in a small incinerator. Using this definition, incineration encompasses the following types of disposal units: backyard burners (residential), industrial incinerators (industrial), and incinerators used by food and department stores, hospitals, and schools (commercial/institutional). Since large municipal incinerators are usually classified as point sources, emissions resulting from disposal in this type of incinerator have not been included in this category.

The quantity of solid waste generated by each sector was estimated for the base year 1976 using population statistics and per capita generation factors for each EPA region. The regional factors were derived from the 1968 National Survey of Community Solid Waste Practices, Interim Report[56] and the Preliminary Data Analysis.[57] Allocation was based on county population.[15]

Since 1976, the previous year's estimates of waste generated by each sector have been updated each year by the same percentage as the relative national percentage increase or decrease in the amount of waste generated (or incinerated) by point sources in each respective sector. For the commercial/institutional and industrial sectors, the annual increase or decrease in waste incinerated by the point source (Reference 55) categories within each sector is used. The annual residential update factor is based on engineering judgement and calculations by the EPA.

Adjustments are made to county estimates, based on information about specific point sources and data submitted by States. If a number of on-site incinerators have been identified as point sources, it may be appropriate to reduce or eliminate area source estimates. Also, it is important to note that estimates of waste generated that are submitted by the States replace the extrapolated data for the year they are submitted. Submitted data are then annually updated by the above method using the relative percentage increase in waste generated.

Previous estimates of waste generated are available from the NEDS point source data -- currently AIRS/FS Point Source Data Files.[20] Annual national update factors are calculated using incineration data from National Air Pollutant Emission Estimates 1940-1989.[55]

Solid Waste: Residential On-Site Incineration

Solid Waste: Residential On-Site Incineration Equations --

County estimates of Residential On-Site Incineration (ROSI) (in short tons) are computed using the following equation:

$$ROSI = \frac{CROSI}{\sum_{n=1}^{c} CROSI_n} \cdot SROSI$$

where: ROSI = Estimated county residential on-site incineration
CROSI = County estimate of residential on-site incineration on AIRS AMS statistical file
SROSI = Reported residential on-site incineration by State
c = Number of counties in State

If SROSI is not available, then the following equation is used:

$$ROSI = \frac{CROSI}{\sum_{n=1}^{cr} CROSI_n} \cdot RROSI$$

where: RROSI = Reported residential on-site incineration by Census Region
cr = Number of counties in Census Region

If RROSI is not available, then the following equation is used:

$$ROSI = \frac{CROSI}{\sum_{n=1}^{nc} CROSI_n} \cdot NROSI$$

where: NROSI = Reported residential on-site incineration for the nation
nc = Number of counties in nation

Solid Waste: Residential On-Site Emission Factors

Emission factors taken from AP-42, Table 2.1-4[8] are used with data from the Inventory of Intermediate Size Incinerators in the United States.[58]

Solid Waste: Industrial On-Site Incineration

Solid Waste: Industrial On-Site Incineration Equations --

County estimates of Industrial On-Site Incineration (IOSI) (in short tons) are computed using the following equation:

$$IOSI = \frac{CIOSI}{\sum_{n=1}^{c} CIOSI_n} \cdot SIOSI$$

where: IOSI = Estimated county industrial on-site incineration
CIOSI = County estimate of industrial on-site incineration on AIRS AMS statistical file
SIOSI = Reported industrial on-site incineration by State
c = Number of counties in State

If SIOSI is not available, then the following equation is used:

$$IOSI = \frac{CIOSI}{\sum_{n=1}^{cr} CIOSI_n} \cdot RIOSI$$

where: RIOSI = Reported industrial on-site incineration by Census Region
cr = Number of counties in Census Region

If RIOSI is not available, then the following equation is used:

$$IOSI = \frac{CIOSI}{\sum_{n=1}^{nc} CIOSI_n} \cdot NIOSI$$

where: NIOSI = Reported industrial on-site incineration for the nation
nc = Number of counties in nation

Solid Waste: Industrial On-Site Incineration Emission Factors

Emission factors taken from AP-42, Table 2.1-4[8] are used with data from the Inventory of Intermediate Size Incinerators in the United States.[58]

Solid Waste: Commercial/Institutional On-Site Incineration

Solid Waste: Commercial/Institutional On-Site Incineration Equations --

County estimates of Commercial/Institutional On-Site Incineration (CIOSI) (in short tons) are computed using the following equation:

$$CIOSI = \frac{CCIOSI}{\sum_{n=1}^{c} CCIOSI_n} \cdot SCIOSI$$

where: CIOSI = Estimated commercial/institutional on-site incineration
CCIOSI = County estimate of commercial/institutional on-site incineration on AIRS AMS statistical file
SCIOSI = Reported commercial/institutional on-site incineration by State
c = Number of counties in State

If SCIOSI is not available, then the following equation is used:

$$CIOSI = \frac{CCIOSI}{\sum_{n=1}^{cr} CCIOSI_n} \cdot RCIOSI$$

where: RCIOSI = Reported commercial/institutional on-site incineration by Census Region
cr = Number of counties in Census Region

If RCIOSI is not available, then the following equation is used:

$$CIOSI = \frac{CCIOSI}{\sum_{n=1}^{nc} CCIOSI_n} \cdot NCIOSI$$

where: NCIOSI = Reported commercial/institutional on-site incineration for the nation
nc = Number of counties in nation

Solid Waste: Commercial/Institutional On-Site Incineration Emission Factors --

Emission factors taken from AP-42, Table 2.1-3[8] are used with data from the Inventory of Intermediate Size Incinerators in the United States.[58]

OPEN BURNING

For the purposes of estimating emissions from open burning practices, open burning refers to uncombined burning of wastes such as leaves, landscape refuse, and other rubbish. Large open burning dumps are usually included under point sources.

The quantity of solid waste burned is computed by updating the previous year's waste generation for each sector. The update factor is determined by engineering judgement. Estimates of the quantity of solid waste burned in the most recent year are obtained from the AIRS/FS Point Source Data Files.[20] Generation factors were originally obtained from data in the 1968 National Survey of Community Solid Waste Practices, Interim Report,[56] and the Preliminary Data Analysis.[57] Allocation was based on county population.

Solid Waste: Residential Open Burning

Solid Waste: Residential Open Burning Equations –

County estimates of Residential Open Burning (ROB) (in short tons) are computed using the following equation:

$$ROB = \frac{CROB}{\sum_{n=1}^{c} CROB_n} \cdot SROB$$

where: ROB = Estimated residential open burning
CROB = County estimate of residential open burning on AIRS AMS statistical file
SROB = Reported residential open burning by State
c = Number of counties in State

If SROB is not available, then the following equation is used:

$$ROB = \frac{CROB}{\sum_{n=1}^{cr} CROB_n} \cdot RROB$$

where: RROB = Reported residential open burning by Census Region
cr = Number of counties in Census Region

If RROB is not available, then the following equation is used:

$$ROB = \frac{CROB}{\sum_{c=1}^{nc} CROB_n} \cdot NROB$$

where: NROB = Reported residential open burning for the nation
nc = Number of counties in nation

Solid Waste: Residential Open Burning Emission Factors --

The emission factors for open burning of refuse and organic materials are taken directly from AP-42, Table 2.4-1 and 2.4-2.[8]

Solid Waste: Industrial Open Burning

Solid Waste: Industrial Open Burning Equations --

County estimates of Industrial Open Burning (IOB) (in short tons) are computed using the following equation:

$$IOB = \frac{CIOB}{\sum_{n=1}^{c} CIOB_n} \cdot SIOB$$

where: IOB = County estimate of industrial open burning
CIOB = County estimate of industrial open burning on AIRS AMS statistical file
SIOB = Reported industrial open burning by State
c = Number of counties in State

If SIOB is not available, then the following equation is used:

$$IOB = \frac{CIOB}{\sum_{n=1}^{cr} CIOB_n} \cdot RIOB$$

where: RIOB = Reported industrial open burning by Census Region
cr = Number of counties in Census Region

If RIOB is not available, then the following equation is used:

$$IOB = \frac{CIOB}{\sum_{n=1}^{nc} CIOB_n} \cdot NIOB$$

where: NIOB = Reported industrial open burning for the nation
nc = Number of counties in nation

Solid Waste: Industrial Open Burning Emission Factors --

The emission factors for open burning of refuse and organic materials are taken directly from AP-42, Table 2.4-2.[8]

Solid Waste: Commercial/Institutional Open Burning

Solid Waste: Commercial/Institutional Open Burning Equations --

County estimates of Commercial/Institutional Open Burning (CIOB) (in short tons) are computed using the following equation:

$$CIOB = \frac{CCIOB}{\sum_{n=1}^{c} CCIOB_n} \cdot SCIOB$$

where: CIOB = County estimate of commercial/institutional open burning
CCIOB = County estimate of commercial/institutional open burning on AIRS AMS statistical file
SCIOB = Reported commercial/institutional open burning by State
c = Number of counties in State

If SCIOB is not available, then the following equation is used:

$$CIOB = \frac{CCIOB}{\sum_{n=1}^{cr} CCIOB_n} \cdot RCIOB$$

where: RCIOB = Reported commercial/institutional open burning by Census Region
cr = Number of counties in Census Region

If RCIOB is not available, then the following equation is used:

$$CIOB = \frac{CCIOB}{\sum_{n=1}^{nc} CCIOB_n} \cdot NCIOB$$

where: NCIOB = Reported commercial/institutional open burning for the nation
nc = Number of counties in nation

Solid Waste: Commercial/Institutional Open Burning Emission Factors --

The emission factors for open burning of refuse and organic materials are taken directly from AP-42, Table 2.4-1.[8]

SECTION 8

NATURAL SOURCES

Natural sources are known to be significant contributors to area source emissions. Natural sources may include the following: biogenic sources, wind erosion, lightning, geothermal sources, and open-water sources. However, while there are numerous methodologies for estimating emissions from natural sources, experts disagree on the most appropriate methodology to use for estimating emissions from this category.

MISCELLANEOUS WIND EROSION

In some areas, large dust emissions are generated as a result of windblown dust. At present, no methodology to estimate activity levels on a county basis is available. No emission factors are available.

SECTION 9

MISCELLANEOUS AREA SOURCES

Area sources which are not defined by Stationary Source Fuel Combustion, Mobile Sources, Industrial Processes, Solvent Utilization, Solid Waste Disposal, or Natural Sources categories are compiled in the Miscellaneous Area Sources category. The importance of these area categories is that, while total emissions from each source are relatively small compared to the major categories, emissions at a particular time may be significant.

As presented, identified miscellaneous area sources are Agricultural Production and Other Combustion. Agricultural Production includes Acres Under Cultivation (Land Tilling) and Agricultural Burning. Other Combustion includes Forest Wildfires, Managed Burning, and Structural Fires.

AGRICULTURE PRODUCTION - CROPS

Acres Under Cultivation (Land Tilling)

Fugitive dust emissions result from various soil preparation operations, which include rough plowing, mulch plowing, and the cutting of narrow slits into the sod for seed and/or fertilizer. Variables known to affect the quantity of dust generated are soil type, surface moisture, resulting tool speed, type of equipment, and wind speed. Activity levels are estimated using the number of acres tilled as obtained from the Census of Agriculture.[39] It was assumed that each acre of harvested cropland is tilled three times per year. The resultant activity levels are reported in thousands of acres.[48]

Acres Under Cultivation Equations --

County estimates of Acres Under Cultivation (AUC) (acres) are computed using the following equation:

$$AUC = \left[\frac{CAHC}{\left(\sum_{n=1}^{c} CAHC_n \right)} \cdot SAHC \right] \cdot 3$$

where: AUC = County estimate of acres under cultivation
CAHC = County estimate of harvested cropland as reported by Census of Agriculture (Reference 38)
SAHC = Reported acres under cultivation by State
c = Number of counties in State

If SAHC is not available, then the following equation is used:

$$AUC = \left[\frac{CAHC}{\left(\sum_{n=1}^{cr} CAHC_n \right)} \cdot RAHC \right] \cdot 3$$

where: RAHC = Reported acres under cultivation by Census Region
cr = Number of counties in Census Region

If RAHC is not available, then the following equation is used:

$$AUC = \left[\frac{CAHC}{\left(\sum_{n=1}^{nc} CAHC_n \right)} \cdot NAHC \right] \cdot 3$$

where: NAHC = Reported acres under cultivation for the nation
nc = Number of counties in nation

Acres Under Cultivation Emission Factors –

The particulate emission factor is found in AP-42, Section 11.2.2.[8]

Agricultural Burning

This miscellaneous area source category estimates emissions from agricultural burning practices routinely used to clear and/or prepare land for planting. Specific operations include grass stubble burning, burning of agricultural crop residues, and burning of standing field crops as part of harvesting (e.g., sugar cane). Emissions estimates are generated by multiplying the number of acres burned in each county by a fuel loading factor and the emission factor for each pollutant.

The original methodology estimated the 1974 activity level in terms of acres burned per State.[59] It is assumed that the total quantity of agricultural products burned in 1974 is the same quantity which will be consumed by fire each year. If no specific crop data were available, it was assumed that the number of acres burned annually are divided equally between sugar cane and field crops. For the purposes of these calculations, fuel loadings for grass burning are 1 to 2 short tons per acre; for sugar cane burning, 6 to 12 short tons per acre.

If new State, regional, or national estimates are available, the existing county data will be updated by the same percentage as the relative State, regional, or national percentage increase or decrease.

Agricultural Field Burning Equations --

County estimates of Agricultural Field Burning (AFB) (acres) are computed using the following equation:

$$AFB = \frac{CAFB}{\left(\sum_{n=1}^{c} CAFB_n\right)} \cdot SAFB$$

where: AFB = County estimate of agricultural field burning
CAFB = County estimate of agricultural field burning on AIRS AMS statistical file
SAFB = Reported agricultural field burning by State
c = Number of counties in State

If SAFB is not available, then the following equation is used:

$$AFB = \frac{CAFB}{\left(\sum_{n=1}^{cr} CAFB_n\right)} \cdot RAFB$$

where: RAFB = Reported agricultural field burning by Census Region
cr = Number of counties in Census Region

If RAFB is not available, then the following equation is used:

$$AFB = \frac{CAFB}{\left(\sum_{n=1}^{nc} CAFB_n\right)} \cdot NAFB$$

where: NAFB = Reported agricultural field burning for the nation
nc = Number of counties in nation

Agricultural Field Burning Emission Factors --

Emission factors are taken from the "Trends" Procedures Document[41] and AP-42, Table 2.4-2.[8]

OTHER COMBUSTION

Area sources which are defined as "Other Combustion" include such categories as forest wildfires, managed burning, and structural fires. The importance of these area categories is that while total emissions from each source are relatively small compared to the major categories, emissions at a particular time may be significant.

Forest Wildfires

Each year emissions are generated by forest wildfires covering large tracts of forested land. For this category, emission estimates are generated by multiplying the number of acres burned per county by a fuel loading factor and then the emission factor.

In the original methodology, State estimates of wildfire activity were allocated to the county level on the basis of forest acreage per county.[59] Wildfire statistics, reported in number of acres burned, were obtained from contact with State forestry officials and from State land use maps for the base year of 1974. Since 1974, the wildfire activity level for each county from the previous year has been updated with wildfire statistics from the U.S. Forest Service.[60] Regional fuel loading factors in short tons per acre for each EPA region from AP-42[8] are applied to State averages within each region to yield short tons consumed.

Forest Wildfire Equations --

County estimates of Forest Acres Burned (FAB) (acres) are computed using the following equation:

$$FAB = \frac{CFAB}{\left(\sum_{n=1}^{c} CFAB_n\right)} \cdot SFAB$$

where: FAB = County estimate of forest acres burned
CFAB = County estimate of forest acres burned on AIRS AMS statistical file
SFAB = Reported forest acres burned by State
c = Number of counties in State

If SFAB is not available, then the following equation is used:

$$FAB = \frac{CFAB}{\left(\sum_{n=1}^{cr} CFAB_n\right)} \cdot RFAB$$

where: RFAB = Reported forest acres burned by Census Region
cr = Number of counties in Census Region

If RFAB is not available, then the following equation is used:

$$FAB = \frac{CFAB}{\left(\sum_{n=1}^{nc} CFAB_n\right)} \cdot NFAB$$

where: NFAB = Reported forest acres burned for the nation
nc = Number of counties in nation

Forest Wildfire Emission Factors --

All emission factors except VOC are taken directly from AP-42, Tables 11.1-1 and 11.1-2.[8] Emission factors are applied to a fuel loading parameter, used as a conversion from acres of land burned to short tons of material burned per acre.

Managed Burning (Slash/Prescribed Burning)

Managed burning activities included in this area source category are slash burning and prescribed burning. In slash burning operations, wastes from logging operations are burned under controlled conditions to reduce fire hazard and remove brush considered to serve host to destructive insects. Prescribed burning is used as a forest management practice to establish favorable seedbeds, remove competing underbrush, accelerate nutrient cycling, control tree pests, and contribute other ecological benefits.

For this category, emissions estimates are generated by multiplying the number of acres burned in each county by a fuel loading factor and the emission factor for each pollutant.

Original State estimates of acreage consumed by both managed burning techniques were determined for the inventory year of 1974.[59] Individual State officials and the U.S. Forest Service were contacted to provide estimates of acreage burned, burning technique, and fuel loading ratios. AMS utilizes State data generated for 1974 which were allocated to the county level according to forest acreage per county as obtained from contact with local officials or State land use maps. If not provided, fuel loadings for slash burning and prescribed burning are 75 and 3 short tons per acre, respectively.

If new State, regional, or national estimates are available, the existing county data will be updated by the same percentage as the relative State, regional, or national percentage increase or decrease.

Managed Burning (Slash/Prescribed Burning) Equations --

County estimates of Managed Burning (MB) (acres) are computed using the following equation:

$$MB = \frac{CMB}{\left(\sum_{n=1}^{c} CMB_n\right)} \cdot SMB$$

where: MB = County estimate of managed burning
CMB = County estimate of managed burning on AIRS AMS statistical file
SMB = Reported managed burning by State
c = Number of counties in State

If SMB is not available, then the following equation is used:

$$MB = \frac{CMB}{\left(\sum_{n=1}^{cr} CMB_n\right)} \cdot RMB$$

where: RMB = Reported managed burning by Census Region
cr = Number of counties in Census Region

If RMB is not available, then the following equation is used:

$$MB = \frac{CMB}{\left(\sum_{n=1}^{nc} CMB_n\right)} \cdot NMB$$

where: NMB = Reported managed burning for the nation
nc = Number of counties in nation

Managed Burning (Slash/Prescribed Burning) Emission Factors --

Particulate and CO emission factors are obtained from the Source Assessment.[61] SO_2 and NO_x emission factors are taken directly from AP-42, Table 11.1-3.[8]

Structural Fires

Structural fires have been included in AMS because building fires have been identified in the production of short-term emissions of air contaminants. Activity level for this category, measured by the total number of fires per county, is multiplied by a loading factor and the emission factor to obtain emissions estimates.

The total number of building fires is obtained from the most recent statistics from the National Fire Protection Association.[62] In absence of county-level allocation data, it is assumed, based on the nationwide figures (Reference 62), that an average of four fires per 1,000 population occur each year. Estimates of the material burned are obtained by multiplying the number of structural fires by a fuel factor of 6.8 short tons of material per fire.

If new State, regional, or national estimates are available, the existing county data will be updated by the same percentage as the relative State, regional, or national percentage increase or decrease.

Structural Fire Equations –

County estimates of Structural Fires (SF) (number of fires) are computed using the following equation:

$$SF = \frac{CSF}{\left(\sum_{n=1}^{c} CSF_n\right)} \cdot SSF$$

where: SF = County estimate of structural fires
CSF = County estimate of structural fires on AIRS AMS statistical file
SSF = Reported structural fires by State
c = Number of counties in State

If SSF is not available, then the following equation is used:

$$SF = \frac{CSF}{\left(\sum_{n=1}^{cr} CSF_n\right)} \cdot RSF$$

where: RSF = Reported structural fires by Census Region
cr = Number of counties in Census Region

If RSF is not available, then the following equation is used:

$$SF = \frac{CSF}{\left(\sum_{n=1}^{nc} CSF_n\right)} \cdot NSF$$

where: NSF = Reported structural fires for the nation
nc = Number of counties in nation

Structural Fire Emission Factors --

Emission factors are based on engineering judgement and background data relating to the National Air Pollutant Emission Estimates, 1940-1989 (Trends).[55]

SECTION 10

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16. ABSTRACT The report provides an understanding of the estimation procedures that will be used by the national component of the Area and Mobile Source Subsystem (AMS) to generate emissions estimates for area and mobile source categories. General methodology and assumptions are discussed as well as the original source of algorithms, activity levels, and emission factors necessary to calculate emissions for each area and mobile source in AMS. The report presents methodologies for all identified sources not defined as point sources. Area and mobile sources are divided into seven major groups: stationary source fuel combustion, mobile sources, industrial processes, solvent utilization, solid waste disposal, natural sources, and miscellaneous area sources. Historically, these methodologies have been referred to as the National Emissions Data System (NEDS) methods and to some extent were described in area source documentation for the 1985 National Acid Precipitation Assessment Program (NAPAP) inventory; however, the NAPAP documentation did not include certain initial data calculations. In addition, over the years many changes have occurred to the sources of the data that feed these methodologies. These initial data calculations and source data changes are included in the report.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
Pollution Emission Estimating Fuels Combustion Industrial Processes Solvents Waste Disposal	Pollution Control Stationary Sources Mobile Sources Emission Factors	13B 11K 14G 15E 21D 21B 13H

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