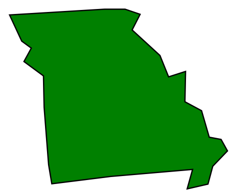
Appendix H.5

MDNR Air Pollution Control Program, *Missouri Statewide Estimates for the 2002 National Emissions Inventory (NEI): Area Sources*

Missouri Department of Natural Resources

Division of Environmental Quality
Air Pollution Control Program



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Missouri Statewide Estimates for the 2002 National Emissions Inventory (NEI)

Area Sources

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1.0 INTRODUCTION

1.1 Purpose of Study

The objective of this report is to document the 2002 Area Source Inventory for the National Emissions Inventory due to EPA every three years. Included are emissions from numerous source categories in each county in the state of Missouri.

1.2 Sources of Emissions

For this inventory, emissions from area sources are estimated collectively for those sources and activities that are too small or too numerous to be handled individually in the point source inventory. Area sources of all criteria pollutant emissions and PM2.5 to be included in this inventory are shown in the following table:

Source Categories	SCCs	PM10	PM2.5	CO	VOC	NOX	SOX
Asphalt Paving	2461021000 2461022000				X		
Dry Cleaning	2420010999				X		
Architectural Surface Coating	2401001000				X		
Autobody Refinishing	2401005000				X		
Consumer/Commercial Solvent Use	2460000000				X		
Bakeries	2302050000				X		
Graphic Arts	2425000000				X		
Solvent Cleaning	2415000000				X		
Leaking USTs	2660000000				X		
Industrial Surface Coating	2401020000				X		
Vehicle Fires	2810050000	X		X	X	X	
Structure Fires	2810030000	X		X	X	X	
Pesticides	2461850000 2461870999				X		
Open Burning	2610030000 2610020000	X		X	X	X	
Wildfires	2810001000	X		X	X	X	
Gasoline Marketing	2501060050 2501060100 2501060201				X		
Landfills	2620030000				X		
Commercial/Marine Vessels	2505020000	X			X	X	
Coal Combustion	2104002000	X	X	X	X	X	X

Source Categories	SCCs	PM10	PM2.5	CO	VOC	NOX	SOX
	2103002000 2102002000						
Natural Gas Combustion	2104006000 2103006000 2102006000	X	X	X	X	X	X
LPG Combustion	2104007000 2103007000 2102007000	X	X	X	X	X	X
Fuel Oil Combustion	2104004000 2103004000 2102004000	X	X	X	X	X	X
Residential Wood Burning	2104008000	X	X	X	X	X	X

1.3 Area Source Estimation Methodologies

Several methodologies were available for estimating the area source activity and emissions: (1) apportioning national or state activity totals to local inventory area; (2) using per capita emission factors; (3) using emissions-per-employee factors; (4) surveying local activity levels; and (5) treating area sources as point sources. Following the methodologies outlined in the Emission Inventory Improvement Program's (EIIP) guidance, appropriate data were collected for each source.

1.4 Allocating Missouri Employees to the Commercial and Industrial Sectors

The North American Industry Classification System (NAICS) is in the process of replacing the Standard Industrial Classification (SIC). Commercial/Institutional sources which were previously designated to be SIC categories 50 through 99, are now designated as NAICS categories 11, and 42-92, as shown in the table below. Industrial sector employment is aggregated for those Missouri employees found working in the NAICS categories 21-33 by the U.S. Census Bureau at http://quickfacts.census.gov/qfd/states/29000.html.
Missouri Department of Economic Development / Economic Research and Information Center employment data for 2002 is at http://www.ded.mo.gov/cgi-bin/meric/es202.pl.

SIC / NAICS Commercial/Institutional & Industrial Categories:

SIC to NAICS Correspondence:

SIC	NAICS	Category	NAICS 11, 42-92 Commercial/Institutional	NAICS 21-33 Industrial
01-09	11	Agriculture, Forestry, Fishing, & Hunting	X	
10-14	21	Mining		X
49	22	Utilities		X
15-17	23	Construction		X

20-39	31-33	Manufacturing		X
50-51	42	Wholesale Trade	X	
52-59	44-45	Retail Trade	X	
41-47	48-49	Transportation and Warehousing	X	
48	51	Information	X	
60-64	52	Finance and Insurance	X	
65-67	53	Real Estate and Rental and Leasing	X	
73,87	54	Professional, Scientific and Technical Services	X	
67	55	Management of Companies and Enterprises	X	
87,78	56	Administrative and Support and Waste Management and Remediation Services	X	
82	61	Educational Services	X	
80	62	Health Care and Social Assistance	X	
79	71	Arts, Entertainment and Recreation	X	
70	72	Accommodation and Food Services	X	
75	81	Other Services (except Public Administration)	X	
91-97	92	Public Administration	X	

1.5 Rule Effectiveness

A rule effectiveness (RE) factor was applied to base year emissions for counties where regulations were in place. RE is a measure of the ability of a regulatory program to achieve all emissions reductions that could be achieved by full compliance with the applicable regulations at all sources at all times. It reflects the assumption that regulations are not 100% effective.

1.6 Double Counting of Emissions

A major concern in the development of an area source inventory is the possibility of double counting emissions. Because some area source methodologies estimate emissions from all sources within a category, emissions already listed in the point source inventory may also be included in the area source inventory. In developing the Missouri area source inventory, possible double counting of emissions was avoided by subtracting emissions appearing in the Missouri state point source inventory from the area source totals for that category (*e.g.,* large dry cleaning facilities, large graphic arts facilities, *etc.*).

1.7 Quality Assurance

To ensure that this emissions inventory if of high quality, certain quality assurance (QA) procedures were implemented at various points in the inventory process. The following quality assurance techniques were used:

- Each algorithm used to calculate emissions was reviewed to ensure its appropriateness and adherence to EIIP guidance.

- Each spreadsheet was reviewed to ensure the proper data, emission factors and algorithms were used.
- Peer review was an essential part of the QA
- All emissions estimates were checked for reasonableness.
- All emissions estimation methods, data collected and emissions calculations were reviewed again during the reporting stage.
- The final data was run through the EPA quality assurance software to identify any errors that occurred as the data was put into NIF format before submission.

The emissions estimates were compared to emissions calculated in 1999 for any large increases or decreases. If there were significant differences in the three-year period the data was subjected to further investigation to ensure accuracy.

1.8 Federal, State and Local Regulations

Federal, State of Missouri and St. Louis area air pollution regulations were reviewed for application to specific area source categories. As shown in the following sections, these regulations have contributed a lot to emission reductions. Categories addressed by these regulations include:

- Commercial and Consumer Products Solvent
- Auto Body Refinishing
- Underground Storage Tanks
- Vehicle Fueling
- Tank Truck Unloading
- Solvent Metal Cleaning
- Dry Cleaning
- Cutback Asphalt Paving
- Open Burning
- Bakery Ovens
- Traffic Coatings

2.0 EMISSIONS ESTIMATES

2.1 Asphalt Paving

2.1.1 Source Description and Emission Controls

Asphalt paving is used to pave, seal, and repair surfaces such as roads, parking lots, drives, walkways, and airport runways. Asphalt concrete used in paving is a mixture of asphalt cement, which is a binder, and an aggregate. Asphalt cement is the semi-solid residual material left from petroleum refining after the lighter and more volatile fractions have been distilled out. Hot-mix asphalt is a mixture of heated asphalt cement and aggregate. Asphalt cutbacks are asphalt cements thinned with petroleum distillates (diluents). Asphalt emulsions are mixtures of asphalt cement with water and emulsifiers. Aggregates used in asphalt cements are typically rock gravel or recycled asphalt pavement, but can also be byproducts from metal ore refining processes.

Aggregate may constitute up to 95 percent by weight of the total mixture. Mixture characteristics for asphalt concrete are determined by the amount and grade of asphalt cement used, the addition of solvent- or soap-based liquefying agents, and the relative amount and types of aggregate used.

Recycled asphalt pavement (RAP) is being used more frequently, partly as a move to reduce solid waste. One source estimates that 90 percent of asphalt processed is RAP. To reuse the asphalt, the RAP is typically pulverized; sorted; mixed with recycling agents such as lime or calcium chloride, or additional aggregate; then applied. The five methods of recycling are: cold planing, hot recycling, hot in-place recycling, cold in-place recycling, and full depth reclamation. All except hot recycling occur at the location where paving is to be done, although material removed during cold planing may be processed at an asphalt plant.

Asphalt concrete is grouped into three general categories: hot-mix, cutback, and emulsified. Each is discussed below.

Hot-Mix Asphalt:

Hot-mix asphalt is the most commonly used paving asphalt for surfaces of 2 to 6 inches thick. Hot-mix asphalt is prepared at a hot-mix asphalt plant by heating asphalt cement before adding the aggregate. To maintain a liquid mixture, these plants must be near to the paving site. In some cases, mobile facilities are used.

Cutback Asphalt:

Cutback asphalt is used in tack and seal operations, in priming roadbeds for hot-mix application, and for paving operations for pavements up to several inches thick. In preparing cutback asphalt, asphalt cement is blended or "cut back" with a diluent, typically from 25 to 45 percent by volume of petroleum distillates, depending on the desired viscosity. Cutback asphalt is prepared at an asphalt plant. There are three types of cutback asphalt cement:

- Rapid Cure (RC) which uses gasoline or naphthas as diluents;
- Medium Cure (MC) which uses kerosene as a diluent; and
- Slow Cure (SC) which uses low volatility fuel solvents as diluents.

Emulsified Asphalt:

Emulsified asphalt is used in most of the same applications as cutback asphalt but is a lower emitting, energy saving, and safer alternative to the cutback asphalt. Instead of blending asphalt cement with petroleum distillates, emulsified asphalt uses a blend of asphalt cement, water and an emulsifying agent, such as soap. Such blends typically contain one-third water, two-thirds asphalt cement and minor amounts of an emulsifier. Some emulsified asphalt may contain up to 12 percent organic solvents by volume. Emulsification is done at an asphalt plant. Emulsified asphalt cures by two methods: water evaporation and, in the case of cationic and anionic emulsions, ionic bonding.

2.1.2 Emission Estimation Methodology

Activity Level

The Missouri Department of Transportation (MODOT) keeps records of amount cutback and emulsified asphalt used in 10 Districts. Since MODOT does not keep records for each county, population figures were used to estimate how much asphalt was used for each county.

Emission Factors

Missouri Department provided all Safety Material Data Sheets (MSDSs) for all types of asphalt used in 2002. Alternative Method 1 of EIIP volume III, Asphalt Paving, was used to come up with emission factors for cutback asphalt. Due to lack of data available for emulsified asphalt an emission factor of 9.2 lb VOC/barrel asphalt used (9.2 lb VOC/350 lb asphalt) was used to calculate VOC emissions from the use of emulsified asphalt in paving activities which was obtained from EIIP volume III.

Assumptions

It was assumed that 5% of asphalt paving was conducted by agencies other than the state's Department of Transportation. After some search on asphalt application practices, it was determined that cutback asphalt is typically applied during November through March. Moreover, emulsified asphalt is typically applied only in warm weather. This corresponds to the months of May through September. Since there is a rule that bans applying cutback asphalt during ozone season in St. Louis Area, it was assumed that there is 80% compliance with this rule.

Sample Calculation (Cole County)

<u>Cutback Asphalt:</u>

VOC Emissions (tons/year) = amount of cutback asphalt (gallons) X population of county / population of district X volume % of diluent X density of diluent X weight % of diluent evaporated / (2000 lb/ton)

Population of Cole County: 71894

Population of Central District: 461578

Types of Asphalt Used in Central District : MC-250 & MC-30

Amount of MC-250 & MC-30 Used in Central District: 64659 gallons

Volume Percent of Diluent: 19%

MC Diluent Density: 6.6755 lb/gallon

Weight Percent Diluent Evaporated: 70%

Activity Days Per Week: 5

Weeks Per Year Used (November to March): 39

VOC Emissions (tons/year) = 64659 gallons X 71894 / 461578 X 0.19 X 6.6755 lb/gallon *.7 / 2000lb/ton = 4.47 tons/year

<u>Emulsified Asphalt:</u>

VOC Emissions (tons/year) = amount of emulsified asphalt (gallons) X density of asphalt (lb/gallon) X Emission Factor (lb/lb) / 2000

Population of Cole County: 71894

Population of Central District: 461578

Amount of Emulsified Asphalt Used in Central District: 7,001,817 lb

VOC Emission Factor = 9.2 lb VOC/350 lb emulsified asphalt

Activity Days Per Week: 7

VOC Emissions (tons/year) = 7001817 X 71894/461578 X 9.2 lb/350 lb / 2000 lb/ton = 14.33 tons/year

2.1.3 Results

The total VOC emissions from asphalt paving for the State of Missouri is 1270.4 tons/year.

2.1.4 References

- *Asphalt Paving*, Volume III: Chapter 17, Final Report, Area Sources Committee EIIP, October 1998.
- *Introduction to Area Source Emission Inventory Development*, Volume III: Chapter 1, Area Sources Committee EIIP, August 1996.
- *Compilation of Air Pollution Emission Factors*. Volume I: Stationary Point and Area Sources. AP-42 (Fifth Edition), U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC, January 1995.
- Customer Service Center, Department of Transportation, Jefferson City, MO.
- East-West Gateway Coordinating Council, St. Louis City, MO.

2.2 Dry Cleaning

2.2.1 Source Description and Emission Control

Dry cleaning is considered a solvent evaporation emission source of VOC. It involves the cleaning of fabrics with non-aqueous organic solvent. The industry is divided into three sectors: coin-operated facilities; commercial operations; and industrial cleaners. Volatile organic solvents that are used as cleaning solvents are emitted during the dry cleaning process. The petroleum solvents most commonly used in dry cleaning are Stoddard solvent (mineral spirit) and 140-F. The synthetic solvents that are used in dry cleaning, PERC, TCA, and CFC-113, are not considered photochemically reactive and should not be included as a source of VOC emissions; PERC and TCA, however, are hazardous air pollutants that should be included in an air toxic inventory. TCA and CFC-113 are ozone-depleting substances, and CFC-113 may be listed in some state regulation as a toxic air pollutant. It is estimated that 82% of all dry cleaning facilities use PERC, 15% use petroleum solvents, 3% use CFC-113, and less than 1% use TCA. However, based on study of national solvent use, 57% of al dry cleaning solvents are petroleum solvents, 39% of the solvents are PERC, and 3 and 1% are TCA and CFC-113, respectively, with a minor amount of unspecified solvents. Small dry cleaning facilities, such as coin-operated sites use PERC exclusively, and larger facilities, such as commercial facilities use petroleum solvents, resulting in this disparity.

2.2.2 Emission Estimation Methodology

Activity Level

The number of employees in dry cleaning facilities with SIC 7216 was used to estimate VOC emissions. The number of employees was obtained from the U.S. Bureau of Census.[1]

Emission Factors

The Emission factor (1800 lb/employee/year) was obtained from EIIP, Dry Cleaning. This emission factor excludes emissions of PERC, TCA, and CFC 113.

Assumptions

It was assumed that coin-operated dry cleaners use PERC exclusively and 15 percent of the remaining dry cleaners use petroleum solvents. According to EIIP volume III[2], there is no seasonal adjustment factor for dry cleaning. In addition, the activity days per week are 5 days.

Sample Calculation (Cole County)

VOC Emissions (tons/year) = [(# of employees) X (percent of facilities using petroleum solvents) X (emission factor) / (2000 lb/ton)

Emission Factor: 1800 lb VOC/employee/yr

Number of Employees with SIC 7216 in Cole County: 59

Percent of Facilities with SIC 7216 that use Petroleum Solvents: 15%

Activity Days Per Week: 5

VOC Emissions (tons/year) = 59 employees X 0.15 X (1800 lb/employee/yr) / (2000 lb/ton) = 7.97 tons/year

2.2.3 Results

Total VOC emissions from dry cleaners for the State of Missouri is 582.26 tons/year.

2.2.4 References

- *U.S. Census Bureau, Department of Commerce, Washington, D.C.*
- *Dry Cleaning, Volume III: Chapter 5, Final Report, Area Sources Committee EIIP, May 1996*

2.3 Architectural Surface Coating

2.3.1 Source Description and Emission Control

Architectural surface coating is considered a solvent evaporation emission of volatile organic compounds (VOC) and is categorized as non-industrial surface coating. Architectural surface coatings, trade paints, are used primarily by homeowners and painting contractors to coat the interior and exterior of houses and buildings and the surfaces of other structures such as pavements, curbs and signs. Volatile organic compounds that are used as solvents in the coatings are emitted during the application of the coating and as the coating dries. The amount of coating used and the VOC content of the coating are the factors that primarily determine emissions from architectural surface coating operations. Secondary sources of VOC emissions are from the solvents used to clean the architectural coating application equipment and VOC released as reaction byproducts while the coating dries and hardens. The resins used in a particular coating determine VOC emitted from this chemical reaction. Since the use of organic solvents in architectural surface coatings is the primary source of emissions, control techniques for this source category involve either product substitution or product reformulation.

2.3.2 Emission Estimation Methodology

Activity Level

The Activity level is based on population and estimated gallons of paint (solvent and water based) used nation wide.[1]

Emission Factors

Emission factors for solvent based and water based paints are 3.87 lb/gallon and 0.74 lb/gallon respectively. All emission factors were obtained from EIIP volume III.[2]

Assumptions

A per capita emission factor was used to calculate emissions from this source category. This per capita usage factor is calculated by dividing the total usage of surface coating materials by the United States population. Activity was also assumed to be uniform 365 days per year.

Sample Calculation (Cole County)

Using the alternative method from the EIIP Volume III, Chapter3[3], the estimated ozone season daily VOC emissions from Cole County can be illustrated as follows:

VOC Emissions (tons/year) = population of county X [(per capita water based factor X water based emission factor) + (population of county X per capita solvent based factor X solvent based emission factor)] / (2000 lbs/ton)

US Population: 288,368,698

Total Paint-water based (gallons): 589,527,000

Total Paint-solvent based (gallons): 119,914,000

Per Capita-water based factor = 589527000 / 288368698 = 2.044 gallons/person

Per Capita-water based factor = 119914000 / 288368698 = 0.416 gallons/person

Paint-water based Emission Factor: 0.74 lb/gallon

Paint-solvent based Emission factor: 3.87 lb/gallon

Population of Cole County, 2002: 71,894

Activity Days per Week: 7

VOC Emissions (ton/year) = 71894 persons X (2.044 gal/person/yr X 0.74 lb/gal + 0.416 gal/person/yr X 3.87 lb/gal) / (2000 lbs/ton) = 112.23 tons/year

2.3.3 Results

Total VOC emissions from architectural surface coating for the State of Missouri is 8855.2 tons/year.

2.3.4 References

- *U.S. Census Bureau, Department of Commerce, Washington D.C.*
- *Architectural Surface Coating, Volume III: Chapter 5, Final Report, Area Sources Committee EIIP, August 1996.*

2.4 Auto Body Refinishing

2.4.1 Source Description and Emission Control

Auto body refinishing operations consist of four steps: (1) vehicle preparation, (2) primer application, (3) topcoat application, and (4) spray equipment cleaning. VOC emissions from automobile refinishing are influenced by several factors. Emissions from surface preparation and coating applications are a function of VOC content of the product used. Emissions are also a function of the transfer efficiency of the spray equipment. Transfer efficiency is the percent of paint solids that actually adheres to the surface being painted. Equipment with lower transfer efficiency would require more material to be sprayed, thus, increasing VOC emissions. Emissions from cleaning operations are dependent on the type of cleanup and housekeeping practices used. There are six main approaches for reducing VOC emissions from auto-body refinishing shops: use of lower-VOC coatings, use of enclosed cleaning devices, increased transfer efficiency, use of lower-VOC primers, use of solvent recovery system, and use of add-on controls for their spray booths such as thermal incineration, catalytic incineration, and carbon absorption. Other housekeeping activities can also be used to reduce emissions from auto body refinishing operations. These activities include tight fitting containers, reducing spills, mixing paint to need, providing training, maintaining rigid control of inventory, etc.

2.4.2 Emission Estimation Methodology

Activity level

The estimated national VOC emissions from auto body refinishing was apportioned to inventory area using employment data with 7532 SIC obtained from Department of Commerce. Data for 2002 was not available therefore data from 1999 was used for purposes of calculation an emission factor only.

Emission Factors

The emission factor is the number of employees in the inventory area divided by the number of employees nationwide with 7532 SIC.

Assumptions

It was assumed that the National VOC emissions from auto body refinishing are directly proportional to employment. It was assumed that the national EPA regulation promulgated on

September 11, 1998 to control VOC emissions from the use of Automobile refinishing coatings would reduce emission by 37%.

Sample Calculation

VOC Emissions (tons/year) = [(# employees in inventory area) / (# employees nation wide) X (national VOC emissions from auto body refinishing) X percent reduction from regulation] / (2000 lb/ton)

Estimated National VOC emissions: 79429.39 tons

Number of Employees Nationwide: 205172

Number of Employees in Cole County: 60

Activity Days Per Week: 5

Percent Emissions Reduction from Regulation: 37%

VOC Emissions (tons/year) = National VOC Emissions / Number of Employees Nationwide X Number of Employees in Cole County = 79429.39 / 205172 X 60 = 23.23 tons/year.

2.4.3 Results

The total VOC emissions from auto-body refinishing in the State of Missouri for 2002 is 1827.0 tons.

2.4.4 References

- *Auto Body Refinishing*, Volume III: Chapter 13, External Draft, Area Sources Committee EIIP, January 1997.
- *Introduction to Area Source Emission Inventory Development*, Volume III: Chapter 1, Area Sources Committee EIIP, August 1996.
- U.S. Census Bureau, Department of Commerce, Washington, D.C.

2.5 Commercial/Consumer Solvent Use

2.5.1 Source Description and Emission Control

Solvents contained in consumer and commercial products are primarily released during product use. Commercial and consumer products included in this category are:

- Household products
- Toiletries
- Aerosol products
- Rubbing compounds

- Windshield washing fluids
- Polishes and waxes
- Non-industrial adhesive
- Space deodorants
- Moth control
- Laundry detergents and treatment

Organic compounds in these products may act either as the carrier for the active product ingredients or as the active ingredients themselves. The organic compounds may be released to the atmosphere through immediate evaporation of an aerosol spray, evaporation after application or direct release in the gaseous phase.

Potential control strategies for VOC emissions from consumer and commercial products include a change in the application method, product substitution, product reformulation, and directions for use, storage, and disposal.

2.5.2 Emission Estimation Methodology

Activity Level

Emissions from consumer and commercial products were estimated using a single per capita emission factor from EIIP volume III, Chapter 5 and population data obtained from the United States Bureau of Census.

Emission Factor

The per capita emission factor for commercial and consumer solvent use is 6.06 lbs./capita/yr. The emission factor was adjusted from 7.84 to 6.06 to avoid double counting with pesticide applications.

Assumption

VOC emissions are proportional to population. It was assumed that the EPA consumer and commercial products regulation finalized on March, 1996 would reduce emissions by 20%.

Sample Calculation (Cole County)

VOC Emissions (tons/year) = population X emission factor X Percent Reduction from Regulation

VOC Emission Factor: 6.06 lb/person/yr

Population of Cole County: 71,894

Percent Reduction of Emission from EPA Regulation: 20%

Activity Days Per Week: 7

Percent Emissions Reduction from Regulation: 20%

VOC Emissions (tons/year) = 71894 persons X 6.06 lb/person/y) X (1 – 0.20) / (2000 lb/ton) = 174.271 tons/year.

2.5.3 Results

The total VOC Emissions from Consumer/Commercial Solvent Use for the State of Missouri is 13750.3 tons/year.

2.5.4 References

- *Consumer and Commercial Solvent Use*, Volume III: Chapter 5, Final Report, Area Sources Committee EIIP, August 1996.
- *Introduction to Area Source Emission Inventory Development*, Volume III: Chapter 1, Area Sources Committee EIIP, August 1996.
- *Compilation of Air Pollution Emission Factors*, Volume I: Stationary Point and Area Sources. AP-42 (Fifth Edition), U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC, January 1995.
- U.S. Bureau of Census, Department of Commerce, Washington, D.C.
- East-West Gateway Coordinating Council, St. Louis City, MO.

2.6 Bakeries

2.6.1 Source Description and Emission Control

The major pollutants emitted from bread baking are VOC emissions, chiefly the ethanol produced as a byproduct of the leavening process. Commercial bread bakeries use four basic dough processes: sponge and dough, straight dough, liquid ferment methods, and no-time dough. Bread in its simplest form requires four ingredients: flour, water, yeast, and salt. The primary emission source at a bakery is the oven. Because the ethanol produced by yeast metabolism is generally liquid at temperature below 77 ^{o}C or 170 ^{o}F, it is not emitted in appreciable amounts until the dough is exposed to high temperature in the oven. Bakery products that are not leavened with yeast do not produce ethanol and should not be considered for the VOC inventory.

2.6.2 Emission Estimation Methodology

Activity Level

VOC emissions from bakeries in Missouri counties were estimated using an employment based emission factor. This emission factor encompasses emissions from liquid ferment, sponge and dough methods. The total amount of VOC emitted by each county was calculated by multiplying the emission factor with the number of employees. The employees for each county were based on the NAICS numbers 3188 obtained from the U.S. Census Bureau.

Emission Factor

The emission factor of 220 tons VOC per employee-year was derived by Radian Corporation in the 1980's.

Assumption

It was assumed that bakery production does not vary from season to season and that the activity days per week are 6 days.

Sample Calculation (Boone County)

VOC Emissions (tons/year) = (# employees - # point source employees) X (emission factor) / 2000 lbs/ton.

Bakeries Employment in Boone County: 59 employees

Bakeries Point Source Employment in Boone County: 0

Emission Factor: 220 lb/employee/yr

Activity Days Per Week: 6

VOC Emissions (tons/year) = (59 – 0) employees X (220 lb/employee/yr) / (2000 lb/ton) = 6.49 tons/year.

2.6.3 Results

The total VOC emissions from bakeries for the State of Missouri is 499.18 tons/year.

2.6.4 References

- *Baked Goods at Commercial/Retail Bakeries*, Volume III: Area Source Method Abstracts, Area Sources Committee EIIP, July1999.
- U.S. Bureau of Census, Department of Commerce, Washington, D.C.
- Compilation of Air Pollution Emission Factors. Volume I: Stationary Point and Area Sources. AP-42 (Fifth Edition), U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC, January 1995.

2.7 Graphic Arts

2.7.1 Source Description and Emission Control

Graphic arts is considered a solvent evaporation source of VOC emissions and includes the printing of news letters, books, magazines, fabric, wall covering and other materials. Graphic arts operations are performed on printing presses that are made up of one or more "units". Each unit can print only one color. The substrate in graphic arts operations is either continuous and called a "web," or individual pieces of substrate called "sheets." The pattern that is printed on the substrate is called the "image." Five basic processes are used in the printing industry, including flexography, letterpress, lithography, rotogravure, and screen process printing. Considerable emissions originate from minor graphic arts applications, including in-house services in nonprinting industries. The predominant emissions from graphic arts printing are VOC contained in the printing inks, fountain solutions and cleaning solutions. Emissions from proofing presses, cleaning operations, ink storage tanks, and ink mixing operations are relatively minor compared to the emissions during the printing process, but they do contribute to overall emissions.

Afterburners, both thermal and catalytic, can be used to control VOC emissions from the heatset web offset lithography, rotogravure printing, and flexography. Refrigeration of the dampening solution is a process change that can achieve approximately 40 percent reduction of the VOC emissions. The use of lower- VOC-containing cleaning solutions can reduce VOC and hazardous air pollutants (HAP) emissions from cleaning operations in all types of printing. Storing cleaning rags in closed containers can control some of the fugitive emissions from cleaning.

2.7.2 Emissions Estimation Methodology

Activity Level

Ink sales nationwide were used to estimate emission from this source category. Ink sales in pounds were obtained from the U.S. Bureau of Census web site. The procedure to estimate emissions from this source category is outlined in EIIP, volume III, Graphic Arts. Given the time limitation and available resources, the first alternative method was used.

Emission Factors

The following emission factors were obtained from EIIP, volume III, Graphic Arts.

Printing Type	% Printing Type	Component Emission Factors Pound VOC Emitted per Pound of Ink Used		
		Ink	Fountain Solution	Cleaning Solution
Rotogravure	22	0.70	NA	0.03
Flexography	16	0.60	NA	0.04
Offset Lithography	35	0.38	2.75	1.23
Letter Press	8	0.24	NA	0.07
Screen	19	0.12	NA	

Assumptions

Number of employees was assumed to be proportional to ink sales.

Sample Calculation

OSD VOC (lb) = (# employees in county – county point source # employees) / total area source # employees X (Total area source ink usage) X ((% rotogravure ink solvent X rotogravure emission factor) + ((% flexography ink solvent X flexography emission factor) + …) / (activity days per week) X (1 yr / 52 week) X (seasonal activity factor) / 0.25

Total Ink Sales in US: 1642500000 lb

Printing Employment in US: 1501714

Printing Employment in State: 43952

Total Ink Sales in State: 48072509.15 lb

Point Source Ink Usage: 45122344.60 lb

Total Area Source Ink Usage: 2950164.54lb

Total Area Source Printing Employment: 21585

Franklin County Printing Employment: 999

Franklin County Point Source Printing Employment: 231

Activity Days Per Week: 5

Seasonal Activity Factor: 0.25

OSD VOC = (999 – 231) / 21585 X 2950164.54 lb X ((0.22 X 0.73) + (0.16 X 0.64) + (0.35 X 4.36) + (0.08 X 0.31) + (0.19 X 0.12)) / (5 days / week) X (1 yr / 52 week) X 0.25 / 0.25 = 741.48 lb/day

2.7.3 References

- *Graphic Arts*, Volume III: Chapter 7, Final Report, Area Sources Committee EIIP, November 1996.
- *Introduction to Area Source Emission Inventory Development*, Volume III: Chapter 1, Area Sources Committee EIIP, August 1996.
- *Compilation of Air Pollution Emission Factors*. Volume I: Stationary Point and Area Sources. AP-42 (Fifth Edition), U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC, January 1995.
- U.S. Bureau of Census, Department of Commerce, Washington, D.C.

2.8 Solvent Cleaning

2.8.1 Source Description and Emission Control

Degreasing operations are considered solvent evaporation emission sources of VOC and employ non-aqueous solvents to remove grease, fats, oil, wax or soil from the surface of metal, glass or plastic articles which are to be electroplated, painted, repaired, inspected, assembled or machined. Degreasing is not associated with any particular industry, but is used in a variety of industries. There are three types of degreasers: small cold cleaners; open top vapor degreasers; and conveyorized degreasers. Open top vapor degreasers and conveyorized degreasers are usually large enough to be considered as point sources of emissions; therefore, only cold cleaners were evaluated for this area source report.
Design features that control solvent emissions from batch cold cleaning machines include increased freeboard ration, covers, internal drainage rack, and visible fill line.

2.8.2 Emission Estimation Methodology

Activity Level

EIIP Volume III, Chapter 6 discusses several methods that can be used to estimate emissions. Given the available data and time limits, the emission factor alternative method was used.

Emission Factor

A per employee emission factor, 87 lb/employee, for total solvent cleaning was used to estimate VOC emissions from solvent cleaning operations.

Sample Calculation

VOC Emissions ton/year = (population of county / population of State X # of Employees in State) X (emission factor)

Population of Cole County: 71894

Population of State of Missouri: 5,672,579

# of Employees in State for Solvent Cleaning: 268,228

Emission Factor: 87 lb/employee/yr

VOC Emissions ton/year = (71894 / 5672579 X 268228) employees X (87 lb/employees/yr) / (2000 lb/ton) = 147.88 tons/year.

2.8.3 Results

The total VOC emissions from solvent cleaning in the State of Missouri is 11667.92 tons/year.

2.8.4 References

- *Solvent Cleaning Use*, Volume III: Chapter 6, Final Report, Area Sources Committee EIIP, September 1997.
- *Introduction to Area Source Emission Inventory Development*, Volume III: Chapter 1, Area Sources Committee EIIP, August 1996.
- *Compilation of Air Pollution Emission Factors*. Volume I: Stationary Point and Area Sources. AP-42 (Fifth Edition), U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC, January 1995.
- United States Bureau of Census, Department of Commerce, Washington, D.C.

2.9 Leaking Underground Storage Tank Removal

2.9.1 Source Description and Emission Control

Leaking underground storage tanks are typically not considered a quantifiable source of emissions until excavation and remediation efforts begin. The majority of air emissions from leaking UST site remediations occur during initial site action, which is typically tank removal. During tank removal, the leaking tank and the surrounding soil are removed and the soil is either treated on-site or transported off site for treatment or disposal in a landfill. Emissions from the soil occur as the tank is being removed and when soil is deposited on the ground before treatment/disposal occurs. The magnitude of VOC emissions during remediation events depends on several factors, most of all which are specific to each site. For this reason, determining emissions for this activity is difficult. Factors influencing VOC emissions from soils include type, concentration, and distribution of contaminants in the soil, the porosity and moisture content of the soil, temperature, wind, shape, and surface area of the soil piles, the type of soil handling equipment used and the duration of the operation.

2.9.2 Emission Estimation Methodology

Activity Level

The number of leaking storage tanks removed in each county in 2002 was obtained from the Missouri Hazardous Waste Program Tanks Section.

Emission Factors

Alternative Method 1 of EIIP, Leaking Underground Storage Tanks was used to determine VOC emissions. An emission factor of 28 lb/day of remediation event was used in calculations.

Sample Calculation

VOC Emissions in tons/year = # of leaking USTs removed X 28 lb/day X # of days per removal / (2000 lb/ton)

Emission Factor: 28 lb/day

# of leaking USTs removed in Cole County: 3

Average # of days to remove tanks: 1

VOC Emissions tons/year = (3 tanks removed) X (28 lb/day/tank removed) X (1 day to remove) = .042 tons/year

2.9.3 Results

The total VOC emissions from the removal leaking underground storage tanks in the State of Missouri is 9.53 tons/year.

2.9.4 References

- U.S. Census Bureau, Department of Commerce, Washington, D.C.
- *Leaking Underground Storage Tanks,* Volume III: Final Report, Area Sources Committee EIIP, December 2000
- State of Missouri Hazardous Waste Management Program- Tanks Section records for 2002.

2.10 Industrial Surface Coating

2.10.1 Source Description and Emission Control

"Surface coating operations involve applying a thin layer of coating (e.g., paint, lacquer, enamel, varnish, etc.) to an object for decorative or protective purposes. The surface coating products include either a water-based or solvent-based liquid carrier that generally evaporates in the drying or curing process.

The use of surface coatings by manufacturing industries and other sectors of the economy is pervasive. Applications include: (1) coatings that are applied during the manufacture of a wide variety of products by Original Equipment Manufacturers (OEMs) including furniture, cans, automobiles, other transportation equipment, machinery, appliances, metal coils, flat wood, wire, and other miscellaneous products, (2) architectural coatings, and (3) special purpose coatings used for applications such as maintenance operations at industrial and other facilities, auto refinishing, traffic paints, marine finishes, and aerosol sprays. For area source purposes, the small industrial surface coating category includes OEM applications, some marine coatings, and maintenance coatings. This category does not include architectural surface coatings, traffic markings, automobile refinishing, or aerosols.

The main approaches for reducing VOC emissions from small industrial surface coating operations are (1) use of lower-VOC coatings, (2) use of enclosed cleaning devices, and (3) increased transfer efficiency. Other housekeeping activities can also be used to reduce emissions from small industrial surface coating operations. These activities include using tight-fitting containers, reducing spills, mixing paint to need, providing operator training, maintaining rigid control of inventory, using proper cleanup methods, etc.

2.10.2 Emission Estimation Methodology

Activity Level

Alternative Method 1 of EIIP volume III, Industrial Surface Coating, was used to estimate VOC emissions. This method is based on the national default per employee emission factors presented in Table 8.5-1 of EIIP volume III, Industrial Surface Coating.

Emission Factors

The following table represents emission factors based on SIC:

Category	SIC Code	Per Employee VOC Emission Factor (lb/yr)
Furniture and Fixtures	25	944
Metal Containers	341	6,029
Automobiles (new)	3711	794
Machinery and Equipment	35	77
Appliances	363	463
Other Transportation Equipment	37, except 3711 and 373	35
Sheet, Strip, and Coil	3479	2,877
Factory Finished Wood	2426-9, 243-245, 2493, 2499	131
Electrical Insulation	3357, 3612	290
Other Product Coatings	NA[a]	NA
High-Performance Maintenance Coatings	NA	NA
Marine Coatings	373	308
Other Special Purpose Coatings	NA	NA

[a]NA = not available, use per capita emission factors from Table 8.5-2

Assumptions

All industrial surface coatings are accounted for in the point source inventory.

2.10.3 Results

Since all emissions of VOC from industrial surface coating are accounted for in the point source inventory the amount of emissions for industrial surface coating in the area source inventory for the State of Missouri is zero.

2.10.4 References

- *Industrial Surface Coating*, Volume III: Chapter 15, Final Report, Area Sources Committee EIIP, September 1997.
- *Introduction to Area Source Emission Inventory Development*, Volume III: Chapter 1, Area Sources Committee EIIP, August 1996.
- *Compilation of Air Pollution Emission Factors.* Volume I: Stationary Point and Area Sources. AP-42 (Fifth Edition), U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC, January 1995.

2.11 Vehicle Fires

2.11.1 Source Description and Emission Control

This emissions source category covers emissions from accidental vehicle fires. Vehicles included are any commercial or private mode of transportation that are authorized for use on public roads. Non-roadway fires such as rail, water, and air transportation are not included. The pollutants emitted that are emitted from vehicle fires that are included in this inventory are PM, CO, and Nox.

2.11.2 Emission Estimation Methodology

Activity Level

Emissions from vehicle fires were calculated using the method suggested in the EIIP guidance document for vehicle fires. First the number of vehicle fires for each county was determined by apportioning national data locally using vehicle miles traveled. An emission factor was then used to determine the amount of pollutants emitted.

Emission Factors

Structural Fire Pollutants	Emission Factor (lbs./ton Material)
PM	100
CO	125
NOx	4

Assumptions

It was assumed that each vehicle has 500 pounds of components that can burn in a fire and that fires occur 7 days a week, 52 weeks a year.

Sample Calculation – Cole County

PM emissions (tons/year) = # of vehicle fires in US X (MO VMT/US VMT) X % of state VMT in Cole County/100 X 500 lb/fire / 2000 lb/ton X emission factor

Number of Vehicle Fires in US: 421440

National VMT: 2,799,258 million

Missouri VMT : 67,632 million

% State VMT in Cole County: 0.907%

PM Emission Factor: 100 lb/ton

Activity Days Per Week: 7

PM Emissions (tons/year) = 421440 Vehicle Fires in US X (67,632 million/2,799,258 million) X 0.907/100 X 500 lb/fire / 2000 lb/ton X 100 lb/ton / 2000 lb/ton = 1.15 tons PM

2.11.3 Results

The emissions from structural fires for the State of Missouri are as follows:

Table 1: Emissions from Structural Fires tons/year

PM	127.28
CO	159.2
NOX	5.09

2.11.4 References

- *Vehicle Fires*, Area Source Method Abstracts, Final Report, Area Sources Committee EIIP, May 2000.
- *Introduction to Area Source Emission Inventory Development, Volume III: Chapter 1*, Area Sources Committee EIIP, August 1996
- *United States Federal Highway Administration web-site.*

2.12 Open Burning - Structure Fires

2.12.1 Source Description and Emission Control

Structural fires or building fires are considered a combustion source of VOC, NOx, CO, and PM emissions. Like forest wildfires, they can produce large amounts of emissions over a short period of time.

2.12.2 Emission Estimation Methodology

Activity Level

Emissions from structural fires were calculated using the second alternative method in *Procedures for the Preparation of Emission Inventories for Precursors of Ozone: Volume I* where an emission factor is applied to an estimate of the number of fires per county and a fuel loading factor (1.15 tons/fire). The number of fires per county was estimated by assuming that an average of 2.3 fires occur per 1,000 people.

Emission Factors

Structural Fire Pollutants	Emission Factor (lbs./ton Material)
VOC	11
CO	60
NOx	1.4
PM10	10.8

Assumptions

The number of fires per county was estimated by assuming that 2.3 fires occur per 1,000 people.

Sample Calculation – Cole County

VOC Emissions (tons/year) = population X # fires per 1000 people X emission factor X fuel loading factor / 2000 lb/ton

Population of Franklin County: 71894

Number of Fires: 0.0023 fire/person/yr

VOC Emission Factor: 11 lb/ton

Fuel Loading Factor: 1.15 tons/fire

Activity Days Per Week: 7

VOC Emissions (tons/year) = 71849 persons X 0.0023 fire/person/yr X 11 lb/ton X 1.15 tons/fire / 2000lb/ton= 1.046 ton/year

2.12.3 Results

The emissions from structural fires for the State of Missouri are as follows:

Table1: Emissions from Structural Fires tons/year

VOC	82.5
CO	450.1
NOX	10.5
PM10	81.0

2.12.4 References

- *Structure Fires*, Volume III: Chapter 18, Final Report, Area Sources Committee EIIP, July 1999.
- *Introduction to Area Source Emission Inventory Development, Volume III: Chapter 1*, Area Sources Committee EIIP, August 1996
- *U.S. Bureau of Census, Department of Commerce, Washington, D.C.*

2.13 Pesticide Application

2.13.1 Source Description and Emission Control

Pesticides are considered an evaporated source of VOC emission and are defined as any substance used to kill or retard the growth of insects, rodents, fungi, weeds or microorganism. Pesticides can be broken down into three chemical categories: synthetics, non-synthetics (petroleum products), and inorganic. Formulations of pesticides are made through the combination of the pest-killing material referred to as the active ingredient, and various solvents, which act as carriers for the pest-killing material, referred to as the inert ingredient. Both types of ingredients contain volatile organic compounds (VOC) that can potentially be emitted to the air either during application or as result of evaporation. The VOC emission rate is influenced by the formulation (solid or solution) and method of application. Pesticide application can be broken down into two users categories: Agricultural and non-agricultural, which includes municipal, commercial, and consumer.

2.13.2 Emission Estimation Methodology

Activity Level

Non-agricultural Pesticides:

Due to difficulties in obtaining accurate information related to non-agricultural pesticides, this category was not separated into municipal, commercial, and consumer subcategories. Emissions were estimated using alternative method 1 given in EIIP, volume III, chapter 9. The method is based on population.

Agricultural Pesticides:

The preferred method was used to estimate emissions form agricultural pesticide. The method is based on pesticide applied, the formulation of the pesticide, and the total acres to which the pesticide was applied. The acreage devoted to crops (alfalfa, corn, cotton, pasture, rice, sorghum, soybeans, tobacco, and wheat) for all counties in 2002 was determined from the state Department of Agricultural (State Crop Statistics, 2002). Pesticide usage data was obtained from the National Center for Food and Agriculture Policy (NCFAP) via the Internet. The data included the pesticide used for each crop, the number of acres treated, and the amount of active ingredient in each pesticide for 1992. Percent active ingredients and VOC contents ware obtained from Chemical & Pharmaceutical Press, Inc. via the Internet.

Emission Factors

Non-agricultural Pesticides:

The emission factor for non-agricultural pesticides is 1.78 pound per person. This emission factor encompasses emissions from municipal, commercial, and consumer pesticide use and was taken from Table 5.4-1 of Chapter 5 (Consumer Solvent Use) of EIIP volume III.

Agricultural Pesticides:

Emission factors are functions of application method and vapor pressure of pesticide active ingredients. Emission factors and typical vapor pressures for some of the active ingredients are given in tables 9.4-4 and 9.4-2 of EIIP, volume III, Pesticide – Agricultural and Non-agricultural, respectively.

Assumptions

It was assumed that the same kinds of pesticides used in 1992 were also used in 2002. It was also assumed that the difference in the amount of pesticide used in 2002 from 1992 is proportional to the difference in acres of crops harvested between 1992 and 2002. Missing active ingredients and VOC contents for some the pesticides were assumed to be 50% each.

Sample Calculation (Cole County)

VOC Emissions (tons/year) = non-agricultural VOC Emissions + agricultural VOC Emissions

Non-agricultural Pesticides:

Population of Cole County: 71894 persons

Emission Factor: 1.78 lb/person/yr

Activity Days Per Week: 6 days

VOC Emissions (ton/year) = population X emission factor = 71894 X 1.78 / 2000 = 63.99 tons/year

Agricultural Pesticides:

Total Pesticides Applied for Sorghum in Missouri

Pesticide	Acres treated	Pounds of active ingredient
2,4-D	43200	27648
ALACHLOR	122400	210528
ATRAZINE	619200	780192
BROMOXYNIL	7200	2376
GLYPHOSATE	14400	10224
METHOLACHLOR	237600	358776
PROPACHLOR	79200	250272
CARBARYL	36000	36000
CARBOFURAN	28800	24192
CHLORPYRIFOS	14400	10224
DIAZINON	14400	7200
MALATHION	21600	21600
METHOMYL	7200	3600
PHORATE	7200	8064
TERBUFOS	7200	5760
Total	1 260 000 Acres	1 756 656 lbs. AI.

Vapor Pressure of 2,4-D: 8.0 X 10^{-6}

Application Method: Soil Incorporation

Emission Factor: 5.4 lb/ton

Percent Active Ingredient (%A.I.): 47.9

Percent Inert Ingredient: 52.1

Pesticide Applied: 27648 lb /0.479 X 1.13 = 16450 lb

Inert Ingredient VOC Content: 21%

Activity Days Per Week: 6 days

VOC Emissions ton/year = Sum[pesticide applied (lb) X [fraction active ingredient X emission factor/2000 + fraction inert ingredient X fraction VOC in formulation]/2000

VOC Emissions from 2,4-D (tons/year) = 16540 lb/year X [0.479 X 5.4 lb/ton / 2000 + 0.521 X 0.21] / = .9 tons/year

VOC Emissions (lb/ozone season day) from 2,4-D = .9 tons/year X (.233/.25) / (6*52) = 7.732 lb/osd

Total VOC Emissions (tons/year) from all pesticide applied to Sorghum = 102.7 tons/year

Total VOC Emissions (tons/year) from all pesticide applied to Sorghum in Cole County = Total VOC Emissions X Total Harvested Sorghum Acres in Franklin County / Total Harvested Sorghum Acres in Missouri

Total Harvested Sorghum Acres in Cole County: 180

Total Harvested Sorghum Acres in Missouri: 153985

VOC Emissions for Cole County for all pesticide applied to Sorghum ton/year = 102.7 ton/year X 180/153985 = .12 tons/year

Total VOC Emissions from all pesticide applied to all crops in Cole County = 10.11 ton/day.

Total VOC Emissions from Agricultural and Non-agricultural pesticide applied in Cole County = 10.11 tons/year + 63.99 ton/year = 74.1 lb/day.

2.13.3 Results

The total VOC emissions from pesticide application for the State of Missouri is 10997.4 ton/year.

2.13.4 References

- *Pesticides- Agricultural & Nonagricultural*, Volume III: Chapter 9, Final Report, Area Sources Committee EIIP, December 1997.
- *Introduction to Area Source Emission Inventory Development*, Volume III: Chapter 1, Area Sources Committee EIIP, August 1996.

- *Compilation of Air Pollution Emission Factors*, Volume I: Stationary Point and Area Sources. AP-42 (Fifth Edition), U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC, January 1995.
- United States Bureau of Census, Department of Commerce, Washington, D.C.
- East-West Gateway Coordinating Council, St. Louis City, MO.

2.14 Open Burning- Residential Solid Waste

2.14.1 Source Description And Emission Control

Open burning is considered a combustion source of VOC, NOx and CO emissions. Open burning may be done in open drums or baskets, yards or dumps. The most effective control technique of open burning emissions is to ban open burning and require management of these wastes by other methods.

2.14.2 Emission Estimation Methodology

Activity Level

<u>Residential Municipal Solid Waste (MSW) Burning</u>

Emission estimates for residential MSW burning were developed by first estimating the amount of waste generated for each county in the United States. The amount of waste generated was estimated using a national average per capita waste generation factor, which is 3.31 lbs/person/day (.6 tons/person/year). To better reflect the actual amount of household residential waste subject to being burned, non-combustibles (glass and metals) and yard waste generation were subtracted out. This factor was then applied to the portion of the county's total population that is considered rural based on 1990 Census data on rural and urban population, since open burning is generally not practiced in urban areas.

For rural populations, it is estimated that 25 to 32 percent of the municipal waste generated is burned. A median value of 28 percent was assumed for the nation, and this correction factor was applied to the total amount of waste generated.

Controls (or burning bans) were accounted for by assuming that no burning takes place in counties where the urban population exceeds 80 percent of the total population (i.e., urban plus rural). Zero open burning emissions were attributed to these counties.

<u>Residential Yard Waste Burning</u>

A national per capita waste generation average daily value of 0.117 tons yard waste/person/year was used as the basis for yard waste open burning emissions. It was assumed that 28 percent of the total yard waste generated is burned and that burning occurs primarily in rural areas.

Controls (or burning bans) were accounted for by assuming that no burning takes place in counties where the urban population exceeds 80 percent of the total population (i.e., urban plus rural). Zero open burning emissions were attributed to these counties.

Emission Factors

Emissions factors for VOC, NOx, CO, and PM10 were obtained from AP- 42 (Table 2.5-1).

	VOC	NOx	CO	PM10
MSW	30	6	85	38
Yard Waste	28	4	140	38

Sample Calculation (Cole County)

Waste Generation Factor (MSW) = .604 tons/person/year

Waste Generation Factor (Yard Waste) = .117 tons/person/year

Population = 71,894

% Rural = 31%

% Waste Generated that is Burned (MSW and Yard Waste) = 28%

MSW Burning PM10 Emissions (tons/year) = Population X % Rural X Waste Generation Factor X % Waste that is Burned X PM10 Emission Factor / 2000

MSW Burning PM10 Emissions (tons/year) = (71894) X (.31) X (.604) X (.28) X (38) / 2000 = 71.26 tons/year

Yard Waste Burning PM10 Emissions (tons/year) = Population X Yard Waste Generation Factor X % Rural X % of Waste that is Burned X PM10 EF /2000

Yard Waste Burning PM10 Emissions (tons/year) = (71894) X (.31) X (.117) X (.28) X (38) / 2000= 13.87 tons/year

2.14.3 Results

Total emissions from open burning of municipal solid waste and yard waste for the State of Missouri are as follows:

	VOC (ton/yr)	Nox (ton/yr)	CO (ton/yr)	PM10 (ton/yr)
MSW	4120.34	6824.07	11674.29	5219.09
Yard Waste	748.65	106.95	3743.27	1016.03

2.14.4 References

- *Open Burning*, Volume III: Chapter 16, Revised Final, Area Sources Committee EIIP, January 2001.
- *Introduction to Area Source Emission Inventory Development*, Volume III: Chapter 1, Area Sources Committee EIIP, August 1996.
- *Compilation of Air Pollution Emission Factors*. Volume I: Stationary Point and Area Sources. AP-42 (Fifth Edition), U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC, January 1995.
- *Procedures for the Preparation of Emission Inventories for Precursors of Ozone:* Volume I, Draft Report, EPA-450/4-91-016, EPA, Research Triangle Park, NC, May 1991.
- *Documentation for the Draft 1999 National Emissions Inventory For Criteria Air Pollutants,* Area Sources, E.H. Pechan & Associates, Inc., NC, September 2001.

2.15 Open Burning-Forest/Wild Fires

2.15.1 Source Description and Emission Control

A wildfire is a large-scale natural combustion process that consumes various ages, sizes, and types of flora growing outdoors in a geographical area. Consequently, wildfires are potential sources of large amounts of air pollutants that should be considered when trying to relate emissions to air quality.

The size and intensity, even the occurrence, of a wildfire depend directly on such variables as meteorological conditions, the species of vegetation involved and their moisture content, and the weight of consumable fuel per acre (available fuel loading). Once a fire begins, the dry combustible material is consumed first. If the energy release is large and of sufficient duration, the drying of green, live material occurs, with subsequent burning of this material as well. Under proper environmental and fuel conditions, this process may initiate a chain reaction that results in a widespread conflagration.

The complete combustion of wildland fuels (forests, grasslands, wetlands) require a heat flux (temperature gradient), adequate oxygen supply, and sufficient burning time. The size and quantity of wildland fuels, meteorological conditions, and topographic features interact to modify the burning behavior as the fire spreads, and the wildfire will attain different degrees of combustion efficiency during its lifetime.

This area source inventory will describe the procedures and applied approach for estimating emissions from this area source of forest fires.

2.15.2 Emission Estimation Methodology

Activity Level

An alternative method was used rather than the two methods provided in the Wildfires and prescribed Burning, EIIP volume III. County emissions from wildfires were calculated based on an annual report, submitted to the Missouri Department of Conservation, from each county reporting the number of acreage burned.

Emission Factors

The following table lists emission factors from the EPA AP-42

Pollutant	Emission Factor (Lbs./ton)	Fuel Loading Factor (tons/acre)
VOC	16	11
NOx	4	11
CO	140	11

Sample Calculation (Cole County)

VOC Emissions (tons/year) = # acres burned X fuel loading factor X Emission Factor / 2000.

Acres Burned in Cole County: 35 acres

VOC Emission Factor: 16 lb/ton

Fuel Loading Factor: 11 tons/acre

VOC Emissions (tons/year) = 35 acres X 11 ton/acre X 16 lb/ton / 2000 lb/ton = 3.1 ton/year.

2.15.3 Results

The emissions from forest fires for the State of Missouri are as follows:

VOC	4389.4 tons/year
CO	38407.6 tons/year
NOX	1097.4 tons/year

2.15.4 References

- "Assessment of Biomass Burning in the United States", Bill Leenhouts, U.S. Fish and Wildlife Service, 1998.
- Compilation of Air Pollution Emission Factors, Volume I: Stationary Point and Area Sources. AP-42 (Fifth Edition), U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC, January 1995.

2.16 Gas Distribution

2.16.1 Source Description and Emission Control

This area source category estimates the volatile organic compound (VOC) emissions resulting from the storage and transfer operations at gasoline dispensing facilities. Emissions from storage and transfer operations include the working losses and breathing losses from underground tanks, vapors displaced through vehicle refueling and spillage.

The area sources of evaporative VOC emissions from the distribution of gasoline that are covered in this category include the following:

- Truck in transit:

  Evaporation of gasoline vapor from loaded tank trucks during transportation of gasoline from the bulk plant/terminal to the service station or other dispensing outlet, and from empty tank trucks returning from service stations to bulk plant/terminals.

  - Stage I:

    Displacement of gasoline vapors from the storage tanks during the transfer of gasoline from tank trucks to storage tanks at the service station.

- Stage II:

  Displacement of gasoline vapors from vehicle gasoline tanks during vehicle refueling. Spillage of gasoline during either delivery activity above may also include. This loss includes prefill and postfill nozzle drip and spitback and overflow from the filler pipe of the vehicle's fuel tank during filling.

  - Storage tank working losses:

    Evaporation of gasoline vapors from the storage tank and from the lines going to the pumps during transfer of gasoline.

VOC emissions from this area source category are influenced by several factors. Fuel volatility measured as Reid vapor pressure (RVP) affects the evaporation rate of gasoline. The technology for loading tank trucks and tanks (splash loading, submerged loading, vapor balance, etc.) affects the release of displacement emissions. Tank characteristics (color and design) affect working losses from aboveground storage tanks.

Emissions from underground tank filling operations at service stations (stage I emissions) can be reduced by the use of a vapor balance system, which consists of a hose that returns gasoline vapors displaced from the underground tanks during filling back to the tank truck, as well as measures to ensure tightness of the truck. The control efficiency of the balance system can range from 93 to 100 percent.

Emissions from vehicle refueling (stage II emissions) also can be reduced by a vapor balance system. During refueling, the vapors displaced from the vehicle fuel tanks are returned to the underground tanks through the use of a special nozzle. Stage 1 controls have been implemented in attainment (Only in Kansas City) and five nonattainment areas. Stage II controls are required in five St. Louis ozone nonattainment areas.

2.16.2 Emission Estimation Methodology

Activity Level

Since volume of gasoline distribution at the county level and information such as sales tax data, gasoline sales data from fuel distributors and retailers are not available, vehicles miles travel (VMT) provided by the Missouri Department of Transportation is the only available information can be used to determine gasoline consumption. It should be noted that the disadvantage of using VMT is that it is a measure of vehicle activity in the area, not a measure of the fuel dispensed in the inventory area. VMT produced by vehicles simply passing through the area that did not refuel in the inventory region would tend to overstate the vehicle refueling activity level.

The VMT used for this inventory was taken from The Missouri Department of Transportation. This 2002 VMT count only takes into account state routes. In order to account for the off-system routes, an additional 30% was added to the state route VMT in order to produce an estimated total VMT for both state routes and off-system routes.

For the St. Louis Non-Attainment area, a much more reliable VMT was used. The East-West Gateway Coordinating Council sponsored a VMT study for the model year 2004. This study was completed by the East-West Gateway Council
of Governments travel demand model, which is currently maintained within CUBE VOYAGER modeling software. The method used is much more accurate and in-depth than the method used by MoDOT in estimating VMT. Therefore, it was used in-place of the MoDOT-generated VMT for the following counties:

- St. Louis City
- St. Louis County
- St. Charles County
- Jefferson County
- Franklin County

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Emission Factors

- Gasoline truck in transit, fuel delivery to outlets and storage tank Breathing Emission Factors

Emission Source	lb/1000 gal. Throughput
Empty Tank Trucks[b]	0.005
Full Tank Trucks[c]	0.005
Filling Underground Tank (Stage I)	
Submerged Filling	7.3
Splash Filling	11.5
Balanced Submerged Filling	0.3
Underground Tank Breathing	1.0

Source : AP-42 Tables 5.2-5, 5.2-7
b & c , Midpoint to typical range provided in AP-42

- Vehicle refueling emission factors

The MOBILE 6 model was used to generate refueling emission factors for gasoline and diesel-fueled vehicles, and emission factors for tailpipe emissions and refueling activities.

The emissions estimation methodologies for this area source category have the following relationship:

Emission = Emission Factor x Activity Level

Where Activity level is total gasoline consumption. The Federal Highway Administration (FHWA) annually publishes Highway Statistics, which contains gasoline consumption data for each state.

Another approach can be used is to use information on annual emissions and fuel consumption for an "Average Passenger Car and Light Truck" published by the U.S. Environmental Protection Agency National Vehicle and Fuel Emissions Laboratory. Since MOBILE 6 is available, this approach was not considered in this study.

Assumptions

The report "1996 Daily Vehicle Miles of Travel Classified by District, County and System" provided by the Missouri Department of Highway Transportation and the "1995 Relationships – Population, Drivers, Vehicles, Fuel, and Travel " was used to derive the gasoline consumption distributed at each county of study in Missouri.

The effective emission reduction for Stage I and II vapor recovery systems is 95% control efficiency.

The average miles-per-gallon fuel efficiency of the gasoline-powered motor fleet. This value, 16.73 miles per gallon, taken from the 1995 Relationships table 5.1. Published by the Missouri Department of Highway and Transportation.

Using EIIP Volume III- Chapter 11 "Gasoline Marketing (Stage I and Stage II)" as a guide to estimate evaporative VOC emissions from the distribution of gasoline that are covered in this chapter.

Gasoline consumption is proportional to gasoline station sales.

There are approximately 1050 gasoline station outlets in five nonattainment areas that implement either Stage I and Stage II; and about 250 gasoline station outlets in Platte, Clay, and Jackson counties that implement Stage I.

Sample Calculation (St. Louis County)

To estimate ozone emissions from gasoline marketing in St. Louis County, the total gasoline distributed (TGD) in this inventory region is

TGD = Vehicle Miles Traveled (VMT) X Average Miles per gallon (EF)
= 47,955,115 miles X 16.73 gallons per mile
= 802,958,274.53 gallons.

a. <u>Emissions from Gasoline Trucks in transit assuming that gasoline consumption is proportional to gasoline station sales.</u>

TTE = TGD X LEF X GTA)/ (TGD X UEF X GTA)

Where:

TTE = Total gasoline emissions from tank trucks in transit (tons per year)
LEF = Loaded tank truck in-transit emission factor from Table 11.3.1 (0.055 lb/1000 gal)
UEF = Unloaded tank truck in-transit emission factor from Table 11.3.1 (0.005 lb/1000 gal)
GTA = 1.25, a national default rate as gasoline transportation adjustment factor.
TTE = ((802,958,274.53 X 0.055 X 1.25) + (802,958,274.53 X 0.005 X 1.25))/ (2000 X 1000)
= 30.11 tpy

b. <u>Emissions from Fuel Delivery to Outlets</u>

FDO = (TGD X FDOE)/ (2000 X 1000)

Where:

FDO = Emissions from Fuel Delivery to Outlets in tons per year (tpy)
FDOE = Uncontrolled gasoline emission factor (27 lbs/1000 gals) X Stage 1 control (90 %) which is 27 lbs/1000 gals X 0.1 = 0.3 lbs/1000 gals

FDO = (802,958,274.53 X 0.3) / (2000 X 1000) = 120.44 tpy

c. Emissions from Storage Tank Breathing

STB = (TGD X STBE)/ (2000 X 1000)

Where:

STB = Emissions from Storage Tank Breathing in ton per year (tpy)
STBE = 1.0lb/1000 gallons taken from Table 11.3-1, EIIP Volume III
STB = (802,958,274.53 X 1.0)/ (2000 X 1000)
= 401.48 tpy

2.16.3 Results

The emissions from Gasoline Distribution for the state of Missouri are as follows:

2.16.4 References

- AP-42 Tables 5.2-5, 5.2-7 b & c , Midpoint to typical range provided in AP-42
- EIIP Volume III- Chapter 11 “Gasoline Marketing (Stage I and Stage II)”
- “2002 Daily Vehicle Miles of Travel Classified by District, County and System”
- Missouri Department of Highway Transportation
- “1995 Relationships – Population, Drivers, Vehicles, Fuel, and Travel”

2.17 Landfills

2.17.1 Source Description and Emission Control

This section covers the estimation of non-point source landfill emission sources. These are generally old, unpermitted landfills and closed landfills not reporting yearly emissions as point sources. A municipal solid waste landfill (MSW) unit is a discrete area of land or an excavation that receives household waste and other types of wastes such as commercial solid waste, nonhazardous sludge, and industrial solid waste. This emission estimation method presented below is not suitable for treatment, storage and disposal facilities (TSDFs) or open dumps.

Landfills are significant sources of methane ($CH4$) and carbon dioxide ($CO2$). In addition to $CH4$ and $CO2$ a small amount of nonmethane organic compounds (NMOCs) are produced. NMOCs include reactive volatile organic compound (VOCs) and hazardous air pollutants (HAPs). Unlike other area sources that may be small sources individually but numerous within the inventory area, only a few landfills may be found within a county area. However, each landfill may emit significant amounts of pollutants. Landfills differ from sources typically categorized as point or major sources in that pollutants are emitted over the area of the landfill, not at a specific point. For those reasons, landfills have been treated as area sources in the past. Recently, air-operating permits have been required for landfills, so that inventory prepares have begun to address them as point sources.

Landfill emissions are collected through either active or passive collection systems. The combustion or purification of the landfill gas can accomplish disposal or treatment of the collected gases.

As mentioned above, this area source category covers emissions from non-point source landfills. Since the method of estimating emissions utilized by this method is based on the average amount of refuse generated per capita, the known gaseous emissions generated by waste disposed of in permitted sanitary landfills must be removed from the totals. This was done by subtracting the reported point source VOC totals for each county from the total estimated by the population method. In certain counties, large regional waste facilities generate VOC emissions which are greater than the area source total. This results in a net negative VOC emissions value for those particular counties. However, negative values cannot be reported on the NIF tables. Only a "zero" value can be reported. To solve this, the negative emissions value was applied to bordering counties in order to balance out the known point-source VOC emissions without creating a negative number for the county in which the point source landfill resides.

2.17.2 Emission Estimation Methodology

Activity Level

The emissions from municipal landfills were calculated by using the population-based waste generation factor. Although landfills can generate emissions for many years, the greatest emissions were assumed to be emitted from waste 25 years old.

Emission Factors

The per capita waste generation factor is from the U.S. EPA Office of Solid Waste and Emergency Response annual publication, Characterization of Municipal Solid Waste in the United States: 1995 Update. The projection data was obtained from the United States Census Bureau.

Assumptions

- Population figures for the inventory year and 24 previous years for a total of 25 years of population data were collected from the U.S. Census Bureau 2000 Census.
- The waste generation factor of 0.69 tons/person/year was multiplied by the population of each year.
- 0.9072 to get megagrams multiplied tons.
- The average annual wastes were calculated and the values were used in the following equation:

$$Q_{CH4} = L_o R (e^{-kc} - e^{-kt})$$

Where:

Q_{CH4} = Methane generation rate at time t, m^3/yr;

L_o = Methane generation potential, m^3 CH4/Mg refuse;

R = Average annual refuse acceptance rate during active life, Mg/yr;

E = Base log, unitless;

k = Methane generation rate constant, yr^{-1};

c = time since landfill closure, years (c=0 for active landfills); and

t = Time since the initial refuse placement, years.

According to EIIP volume III there is a 0.25 seasonal activity factor.

Sample Calculations (Franklin County)

Using the per capita waste generation factor from the U.S. EPA Office of Solid Waste and Emergency Response annual publication, *Characterization of Municipal Solid Waste in the United States: 1995 Update and the* population data obtained from the United States Census Bureau.
The estimated emissions from the Franklin County inventory area can be illustrated, as follows:

Waste Generation Factor: 0.69 tons/person/yr

Franklin's Average Annual Refuse Acceptance Rate during Active Life: 46730 Mg/yr.

Assuming that c = 0, and t = 6

Methane generation rate at time t, m^3/yr:

$$Q_{CH4} = 125*46730*(1 - e^{-0.04*6}) = 1246373$$

Non-methanogenic organic compound emission rate (Q_{NMOC}), m^3/yr

$$Q_{NMOC} = 2*Q_{CH4}*C_{NMOC}/(1*10^6)$$

Where;

C_{NMOC} = Total NMOC concentration in landfill gas, ppmv as hexane = 1170

$Q_{NMOC} = 2*1246373*1170/(1*10^6) = 2917$ m^3/yr

The mass emission per year of total NMOCs, kg/yr

$M_{NMOC} = Q_{NMOC}*1050.2/(273+T)$

Where;
T = Temperature of landfill gas (^oC)
$M_{NMOC} = 2917*1050.2/(273+25) = 22648$ kg/yr

Franklin's Uncontrolled NMOC emission Reported as HAPs – H_{NMOC}: 1150 lbs./day

VOC Emission Factor = $[M_{NMOC} - H_{NMOC}]/R$ = [22648 – 1150]/ 46730 = 0.46

VOC Emissions = R * 0.46/365 = 46730 * 0.46/ 365 = 59 lbs./day

VOC Actual Emissions = VOC Emissions Area Source – VOC Emission Point Source

VOC Actual Emissions = 59 – 20 = 39 lbs./day

2.17.3 Results

The total VOC emissions from area source landfills in the state of Missouri is 455.38 tons/year.

2.17.4 References

- Missouri Solid Waste Diversion and Recycling
- Status Report For Calendar Year – 2001
- The U.S. EPA Office of Solid Waste and Emergency Response annual publication, Characterization of Municipal Solid Waste in the United States: 1995 Update. EPA 530-R-95-001 PB96-152 160. March
- Landfills, Volume III: Chapter 15, Final Report, Area Sources Committee EIIP, September 1997
- Introduction to Area Source Emission Inventory Development, Volume III: Chapter 1, Area Sources Committee EIIP, 2002
- Compilation of Air Pollution Emission Factors. Volume I: Stationary Point and Area Sources. AP-42 (Fifth Edition), U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC, January 1995
- United States Bureau of Census

2.18 Liquefied Petroleum Gas (LPG) Combustion

2.18.1 Fuel Description

This source category covers air emissions from liquefied petroleum gas (LPG) combustion in the residential, commercial/institutional, and small industrial sectors for space heating, water heating, or cooking. This category includes small boilers, furnaces, heaters and other heating units that are not inventoried as point sources. Residential and commercial sectors comprise housing units; wholesale and retail businesses; health institutions; social and educational institutions; and federal, state and local government institutions (e.g., military installations, prisons, office buildings).

LPG consists of propane, propylene, butane, and butylenes; the products used for domestic heating are composed primarily of propane. The largest market for LPG is the domestic/commercial market. There are three grades of LPG available as heating fuels: commercial-grade propane, engine fuel-grade propane, and commercial-grade butane. The second largest use of LPG is by the chemical industry, where it is used as a petrochemical feedstock, and the agriculture industry. Propane is also used as an engine fuel as an alternative to gasoline and as a standby fuel for facilities that have interruptible LPG service contracts.

2.18.2 Emission Estimation Methodology

The combustion processes that use LPG are very similar to those that use natural gas. LPG is considered a "clean" fuel because it does not produce visible emissions. The criteria pollutants emitted, VOC, NOx, CO, SO2, and PM, are produced in small amounts.

Activity

Residential Sources:

The 2000 Census Bureau data contains information on the primary fuel combusted by houses by county. *Census 2000 – American Fact Finder - Summary File 3, Table H40. House Heating Fuel* provides data on the number of occupied housing units in each county using the following categories of fuels: Utility gas (assumed to be natural gas), bottled, tank, or LP gas, electricity, fuel oil, kerosene, etc., coal or coke, wood, solar energy, other fuel, or no fuel used.

The LPG burned at the state level is apportioned to the county level using U.S. Census data on households that use LPG as a primary fuel. The Department of Energy (DOE) Energy Information Administration (EIA) provides state-level fuel consumption for residential, commercial, and industrial sectors. The equation is:

$$\text{County LPG use} = \text{Statewide LPG use} \times \frac{\text{County LPG burning households}}{\text{State LPG burning households}}$$

Commercial/Institutional Sources:

2002 employment data was obtained from the Missouri Economic Research and Information Center (MERIC). Commercial/Institutional and Industrial sector employment was aggregated for Missouri employees working in the NAICS categories as outlined in Section 1.3.1.

The LPG burned at the state level is apportioned to the county level using 2002 MERIC employment data in NAICS categories 11, and 42-92. The equation is:

County LPG Use = Statewide LPG use X $\frac{\text{NAICS 11, 42-92 employees by county}}{\text{NAICS 11, 42-92 employees by state}}$

Industrial sources:

The LPG burned at the state level is apportioned to the county level using 2002 MERIC employment data in NAICS categories 21-33. The equation is:

County LPG use = Statewide LPG use X $\frac{\text{NAICS 21-33 employees by county}}{\text{NAICS 21-33 employees by state}}$

LPG Emission Factors

Emission factors for combustion of LPG in commercial boilers are presented in Table 1.5-1 of Section 1.5 of *AP-42* (EPA, 1998a). Because no emission factors were located for the combustion of LPG for residential consumption, emission factors for commercial boilers are used for residential emissions.

Table 2.18-1. LPG Combustion Emission Factors

Point SCC:	n/a	10301002	10201002
Area SCC:	2104007000	2103007000	2102007000
Pollutant	Residential	Commercial	Industrial
	EF (lb/1000 Gallons)	EF (lb/1000 Gallons)	EF (lb/1000 Gallons)
VOC	0.5	0.5	0.5
NOX	14	14	19
CO	1.9	1.9	3.2
SO2	0.016	0.016	0.016
PM10 & 2.5 PRI	7.6	7.6	7.6
PM10 & 2.5 (Filterable)	1.9	1.9	1.9
PM10 & 2.5 (Condensable)	5.7	5.7	5.7

The emission factor for SO2 requires knowledge of the sulfur content of the LPG. The sulfur content of LPG is very low. EPA's SO2 emissions estimate is derived from the sulfur content of the propane fuel. With 90% of LPG comprised of propane, the EPA's propane emissions factor is a reasonable value for LPG emissions rates. The obtained estimates range from approximately 0.0185% sulfur by weight to 0.060125% sulfur by weight. The statistical average or arithmetic mean of these four estimates is 0.0333% sulfur by weight. The wide range of emissions factors for SO2 makes it difficult to determine a representative estimate for the emissions factor and the very small net effect of any energy-efficiency standard argue against making a significant research effort. Therefore, the AP-42 emission factor used in the example of 0.016 lb of SO_2/1000 gallon will be used.

Temporal Adjustments for Ozone

For the 8-hour ozone NAAQS emission inventory, EPA guidance calls for CO, NOx, and VOC emissions to be reported as actual annual and actual summer weekday. Summer weekday emissions are defined as an average day's emissions for a typical summer day during the ozone season, typically defined as the months of June, July, and August. Fossil fuel consumption drops substantially during the summer months when the need for space heating is virtually zero. A seasonal activity factor is therefore needed to reflect the proportion of fuel consumption that takes place in June-August relative to annual consumption and emissions.

The best way to determine the seasonal activity factor is to obtain activity data that are specific for the location and season of interest. The most specific activity data available is Missouri monthly natural gas consumption data for 2002 for the residential, commercial, and industrial sectors obtained from the EIA. This same activity data was used to derive a residential, commercial/institutional, and industrial seasonal activity factor (SAF) for all the area source fossil fuel combustion calculations, which should have very close to the same proportion of fuel consumed in June-August. Monthly natural gas consumption data for 2002 for the residential, commercial, and industrial sectors were obtained from the EIA table, *Natural Gas Production & Use by Missouri*.

Residential:

Average ozone summer day (OSD) emission estimates were calculated using the equation:

$$\text{Ave. emissions per summer day} = \frac{\text{Annual emissions} \times \dfrac{\text{LPG use in June-August}}{\text{LPG use in 2002}}}{(\text{Operating days/season} = 92)}$$

(LPG used in June-August)/(LPG used in 2002) is the Seasonal Activity Factor SAF=0.0655.

The number of activity days per week for residential activities are 7.

Commercial/Institutional:

Average ozone summer day (OSD) emission estimates were calculated using the equation:

$$\text{Ave. emissions per summer day} = \frac{\text{Annual emissions} \times \dfrac{\text{LPG use in June-August}}{\text{LPG use in 2002}}}{(\text{Operating days/season} = 79)}$$

(LPG used in June-August)/(LPG used in 2002) is the Seasonal Activity Factor SAF=0.0950.

The number activity days per week for commercial/industrial activities are considered to be 6, although this would not hold true for hospitals, nursing homes, and most stores would be 7, while most schools would be 5.

Industrial:

Average ozone summer day (OSD) emission estimates were calculated using the equation:

$$\text{Ave. emissions per summer day} = \frac{\text{Annual emissions} \times \frac{\text{LPG use in June-August}}{\text{LPG use in 2002}}}{\text{(Operating days/season = 79)}}$$

(LPG used in June-August)/(LPG used in 2002) is the Seasonal Activity Factor SAF=0.2010.

The number of activity days per week for industrial activities are considered to be an average of about 6.

Sample Calculations (Cole County)

Residential LPG:

Annual VOC (tons/year) = (amount of LPG used in Missouri per yr) X ((# houses using LPG in county) / (# houses using LPG in Missouri)) X (VOC emission factor(lb/1000 Gallons)) / (2000 lb/ton)

OSD VOC (lb/day) = Annual VOC (tons/year) X 2000 lb/ton X SAF / (Operating days/season)

Amount of LPG Used in Missouri: 251,412 1000 Gallons

Number of Houses Using LPG in Missouri: 293,603

Number of Houses Using LPG in Cole County: 2,977

VOC Emission Factor: 0.5 lb/1000 Gallons

Residential Seasonal Activity Factor (SAF): = 0.0655

Operating days/season: 92

Annual VOC (tons/year) = 251,412 1000 Gallons/year X 2,977 houses / 293,603 houses X 0.5 lb/1000 Gallons / 2000 lb/ton = 0.64 tons /year

OSD VOC (lb/day) = 0.64 tons /year X 2000 lb/ton X 0.0655 / 92 = 0.91 lb/day

Commercial/Institutional LPG:

Annual VOC (tons/year) = (amount of LPG used in Missouri per yr) X (# employees using LPG in county) / (# employees using LPG in Missouri) X (VOC emission factor(lb/1000 Gallons)) / (2000 lb/ton)

OSD VOC (lb/day) = Annual VOC (tons/year) X 2000 lb/ton X SAF / Operating days/season

Amount of LPG Used in Missouri: 44,318 1000 Gallons

Number of Comm./Inst. Employees in Missouri: 2,063,988

Number of Comm./Inst. Employees in Cole County: 46,695

VOC Emission Factor: 0.5 lb/1000 Gallons

Activity Days Per Week: 6

Active Days During Ozone Season (June-August): 79

Commercial/Industrial Seasonal Activity Factor (SAF): 0.0950

Annual VOC (tons/year) = 44,318 1000 Gallons X (46,695 / 2,063,988) X (0.5 lb/1000 Gallons) / (2000 lb/ton) = 0.25 tons/year

OSD VOC (lb/day) = 0.25 tons/year X 2000 lb/ton X 0.0950 / 79 = 0.60 lb/day

Industrial LPG:

Annual VOC (tons/year) = (amount of LPG used in Missouri per yr) X (# employees using LPG in county) / (# employees using LPG in Missouri) X (VOC emission factor (lb/1000 Gallons)) / (2000 lb/ton)

OSD VOC (lb/day) = Annual VOC (tons/year) X 2000 lb/ton X SAF / Operating days/season

Amount of LPG Used in Missouri: 151,152 1000 Gallons

Number of Employees in Industrial Sector in Missouri: 462,567

Number of Employees in Industrial Sector in Cole County: 5,621

VOC Emission Factor: 0.5 lb/1000 Gallons

Industrial Seasonal Activity Factor (SAF) = 0.2010

Activity Days Per Week: 6

Active Days During Ozone Season (June-August): 79

Annual VOC (tons/year) = 151,152 1000 Gallons X (5,621 / 462,567) X (0.5 lb/1000 Gallons) / (2000 lb/ton) = 0.46 tons/year

OSD VOC (lb/day) = 0.46 tons/year X 2000 lb/ton X 0.2010 / 79 = 2.34 lb/day

2.18.3 Results

The emissions from LPG Combustion for the State of Missouri are as follows:

2002 Emissions from LPG Combustion in Missouri (Tons/Year)

	VOC	NOx	CO	SO2	PM10	PM2.5
Residential	62.8530	1,759.884	238.8414	2.0113	955.3656	955.3656
Commercial	11.08	310.23	42.10	0.35	168.41	168.41
Industrial	37.7879	1,435.94	241.84	1.21	574.38	574.38

2.18.4 References

Energy Information Administration (EIA), U.S. Department of Energy, Washington, D.C.
http://www.eia.doe.gov/emeu/states/sep_use/total/pdf/use_mo.pdf
http://www.eia.doe.gov/emeu/states/_use_multistate.html#use_technotes
LPG Sulfur content discussed in
http://www.eere.energy.gov/buildings/appliance_standards/residential/pdfs/K-2.pdf

The U.S Bureau of Census, Department of Commerce, Washington, D.C.
Residential Commercial/Institutional Natural Gas and Liquefied Petroleum Gas (LPG) Combustion, Volume III: Area Source Method Abstracts, Area Sources Committee EIIP, July 1999.

Introduction to Area Source Emission Inventory Development, Volume III: Chapter 1, Area Sources Committee EIIP, August 1996.

Compilation of Air Pollution Emission Factors. Volume I: Stationary Point and Area Sources. AP-42 (Fifth Edition), U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC, January 1995.
East-West Gateway Coordinating Council, St. Louis City, MO.

2.19 Natural Gas Combustion

2.19.1 Source Description and Emission Control

Natural gas is one of the major combustion fuels used throughout the country. It is used to generate industrial and utility electrical power, produce industrial process steam, for residential and commercial space heating, water heating, and cooking. Natural gas consists of a high percentage of methane (generally above 85 percent) and varying amounts of ethane, propane, butane, and inerts (typically nitrogen, carbon dioxide, and helium). Air pollutants emitted from natural gas-fired combustion (e.g., boilers, furnaces, etc.) include carbon monoxide (CO2), nitrogen oxides (NOx), sulfur oxides (SOx), volatile organic compounds (VOCs), and particulate matter (PM10 and PM2.5). Residential and commercial sectors comprise housing units; wholesale and retail businesses; health institutions; social and educational institutions; and federal, state and local government institutions (e.g., military installations, prisons, office buildings). In addition, the commercial/institutional sector includes agriculture, forestry, and fishing.

2.19.2 Emission Estimation Methodology

Activity

The Department of Energy (DOE) Energy Information Administration (EIA) provides state-level fuel consumption for residential, commercial, and industrial sectors. The *Natural Gas Production & Use by Missouri* table summarizes both monthly and annual natural gas consumption. EIA does not collect the information necessary to separate natural gas combustion into residential and commercial/institutional consumption, but disaggregates the data based on assumptions and statistical methods applicable to the national level that may not be correct for the inventory area.

<u>Residential Sources:</u>

The 2000 Census Bureau data contains information on the primary fuel combusted by houses by county. *Census 2000 – American Fact Finder - Summary File 3, Table H40. House Heating Fuel* provides data on the number of occupied housing units in each county using the following categories of fuels: Utility gas (assumed to be natural gas), bottled, tank, or LP gas, electricity, fuel oil, kerosene, etc., coal or coke, wood, solar energy, other fuel, or no fuel used.

The natural gas burned at the state level is apportioned to the county level using U.S. Census data on households that use natural gas as a primary fuel. The equation is:

$$\text{County Natural Gas use} = \text{Statewide N. Gas use} \times \frac{\text{County N. Gas burning households}}{\text{State N. Gas burning households}}$$

<u>Commercial/Institutional Sources:</u>

2002 employment data was obtained from the Missouri Economic Research and Information Center (MERIC). Commercial/Institutional and Industrial sector employment was aggregated for Missouri employees working in the NAICS categories as outlined in Section 1.3.1.

The natural gas burned at the state level is apportioned to the county level using 2002 MERIC employment data in NAICS categories 11, and 42-92. The equation is:

$$\text{County Natural Gas Use} = \text{Statewide Nat. Gas use} \times \frac{\text{NAICS 11, 42-92 employees by county}}{\text{NAICS 11, 42-92 employees by state}}$$

Industrial sources:

The natural gas burned at the state level is apportioned to the county level using 2002 MERIC employment data in NAICS categories 21-33. The equation is:

$$\text{County Natural Gas use} = \text{Statewide N. Gas use} \times \frac{\text{NAICS 21-33 employees by county}}{\text{NAICS 21-33 employees by state}}$$

Emission Factors

Natural gas combustion emission factors for VOC, NOx, CO, SO2, and PM are shown in Table 2.15-1. These were obtained from AP-42/FIRE where provided. Those emission factors not in AP-42 were determined in discussions with Pechan Associates, who is verifying and consolidating all the CenRAP states 2002 NEI submittals.

Table 2.19-1. Natural Gas Combustion Emission Factors

Point SCC:	**n/a**	**10300603**	**10200602**
Area SCC:	**2104006000**	**2103006000**	**2102006000**
Pollutant	**Residential EF (lb/MMCF)**	**Commercial EF (lb/MMCF)**	**Industrial EF (lb/MMCF)**
CO	40	84	84
NOX	94	100	100
SO2	0.6	0.6	0.6
VOC	5.5	5.5	5.5
PM10 & 2.5 PRI (Total)	7.6	7.6	7.6
PM10 & 2.5 (Filterable)	1.9	1.9	1.9
PM10 & 2.5 (Condensable)	5.7	5.7	5.7

The SO_2 emission factor assumes that the sulfur content of natural gas is 2,000 grains/$10^6 ft^3$. The filterable PM10 and PM2.5 emission factors are identical as all PM (from natural gas combustion) are assumed to be less than 1.0 micrometers in diameter.

Temporal Adjustments for Ozone

For the 8-hour ozone NAAQS emission inventory, EPA guidance calls for CO, NOx, and VOC emissions to be reported as actual annual and actual summer weekday. Summer weekday emissions are defined as an average day's emissions for a typical summer day during the ozone season, typically defined as the months of June, July, and August. Fossil fuel consumption drops substantially during the summer months when the need for space heating is virtually zero. A seasonal activity factor is therefore needed to reflect the proportion of fuel consumption that takes place in June-August relative to annual consumption and emissions.

The best way to determine the seasonal activity factor is to obtain activity data that are specific for the location and season of interest. The most specific activity data available is Missouri monthly natural gas consumption data for 2002 for the residential, commercial, and industrial sectors obtained from the EIA. This same activity data was used to derive a residential, commercial/institutional, and industrial seasonal activity factor (SAF) for all the area source fossil fuel combustion calculations, which should have very close to the same proportion of fuel consumed in June-August. Monthly natural gas consumption data for 2002 for the residential, commercial, and industrial sectors were obtained from the EIA table, *Natural Gas Production & Use by Missouri*.

Residential:

Average ozone summer day (OSD) emission estimates were calculated using the equation:

$$\text{Ave. emissions per summer day} = \frac{\text{Annual emissions} \times \dfrac{\text{Gas use in June-August}}{\text{Gas use in 2002}}}{(\text{Operating days/season} = 92)}$$

(Gas used in June-August)/(Gas used in 2002) is the Seasonal Activity Factor (SAF)=0.0655.

The number of activity days per week for residential activities are 7.

Commercial/Institutional:

Average ozone summer day (OSD) emission estimates were calculated using the equation:

$$\text{Ave. emissions per summer day} = \frac{\text{Annual emissions} \times \dfrac{\text{Gas use in June-August}}{\text{Gas use in 2002}}}{(\text{Operating days/season} = 79)}$$

(Gas used in June-August)/(Gas used in 2002) is the Seasonal Activity Factor (SAF)=0.0950.

The number activity days per week for commercial/industrial activities are considered to be 6, although this would not hold true for hospitals, nursing homes, and most stores would be 7, while most schools would be 5.

Industrial:

Average ozone summer day (OSD) emission estimates were calculated using the equation:

$$\text{Ave. emissions per} = \text{Annual emissions} \times \frac{\text{Gas use in June-August}}{\text{Gas use in 2002}}$$

summer day (Operating days/season = 79)

(Gas used in June-August)/(Gas used in 2002) is the Seasonal Activity Factor (SAF)=0.2010.

The number of activity days per week for industrial activities are considered to be an average of about 6.

Sample Calculations (Cole County)

Residential Natural Gas:

Annual VOC (tons/year) = (amount of N. Gas used in Missouri per yr) X ((# houses using N. Gas in county) / (# houses using N. Gas in Missouri)) X (VOC emission factor) / 2000 lb/ton

OSD VOC (lb/day) = Annual VOC (tons/year) X 2000 lb/ton X SAF / (Operating days/season)

Amount of N. Gas Used in Missouri: 115,721 MMCF

Amount of N. Gas Used in Missouri in June-Aug.: 7,576 MMCF

Residential Seasonal Activity Factor (SAF): 7,576 / 115,721 = 0.0655

Number of Houses Using N. Gas in Missouri: 1,261,397

Number of Houses Using N. Gas in Cole County: 11,822

VOC Emission Factor: 5.5 lb/MMCF

Operating days/season: 92

Annual VOC (tons/year) = 115,721 MMCF/year X 11,822 houses / 1,261,397 houses X 5.5 lb/MMCF / 2000 lb/ton = 2.98 tons /year

OSD VOC (lb/day) = 2.98 tons /year X 2000 lb/ton X 0.0655 / 92 = 4.25 lb/day

Commercial/Institutional Natural Gas:

Annual VOC (tons/year) = (amount of N. Gas used in Missouri per yr) X (# employees using N. Gas in county) / (# employees using N. Gas in Missouri) X (VOC emission factor(lb/MMCF)) / (2000 lb/ton)

OSD VOC (lb/day) = Annual VOC (tons/year) X 2000 lb/ton X SAF / Operating days/season

Amount of N. Gas Used in Missouri: 64,703 MMCF

Number of Comm./Inst. Employees Using N. Gas in Missouri: 2,063,988

Number of Comm./Inst. Employees Using N. Gas in Cole County: 46,695

VOC Emission Factor: 5.5 lb/MMCF

Activity Days Per Week: 6

Active Days During Ozone Season (June-August): 79

Commercial/Industrial Seasonal Activity Factor (SAF): 0.0950

Annual VOC (tons/year) = 64,703 MMCF X (46,695 / 2,063,988) X (5.5 lb/MMCF) / (2000 lb/ton) = 4.03 tons/year

OSD VOC = 64,703 MMCF X (46,695 / 2,063,988) X (5.5 lb/MMCF) X 0.0950 / 79
= 9.68 lb/day

Industrial Natural Gas:

Annual VOC (tons/year) = (amount of N. Gas used in Missouri per yr) X (# employees using N. Gas in county) / (# employees using N. Gas in Missouri) X (VOC emission factor (lb/MMCF)) / (2000 lb/ton)

OSD VOC (lb/day) = Annual VOC (tons/year) X 2000 lb/ton X SAF / Operating days/season

Amount of N. Gas Used in Missouri: 65,903 MMCF

Number of Employees in Industrial Sector in Missouri: 462,567

Number of Employees in Industrial Sector in Cole County: 5,621

VOC Emission Factor: 5.5 lb/MMCF

Industrial Seasonal Activity Factor (SAF) = 0.2010

Activity Days Per Week: 6

Active Days During Ozone Season (June-August): 79

Annual VOC (tons/year) = 65,903 MMCF X (5,621 / 462,567) X (5.5 lb/MMCF) / (2000 lb/ton) = 2.20 tons/year

OSD VOC (lb/day) = 2.20 tons/year X 2000 lb/ton X 0.2010 / 79 = 11.21 lb/day

2.19.3 Results

The emissions from Natural Gas Combustion for the State of Missouri are as follows:

2002 Emissions from Natural Gas Combustion in Missouri (Tons/Year)

	VOC	NOx	CO	SO2	PM10	PM2.5
Residential	318.23	5438.89	2314.42	34.72	439.74	439.74
Commercial	177.93	3235.15	2717.53	19.41	245.87	245.87
Industrial	181.23	3295.15	2,767.93	19.77	250.43	250.43

2.19.4 References

1999 National Emission Inventory (NEI) version 3.0 Draft National Criteria Inventory for Residential Fossil Fuel Combustion, Area Source Method Abstracts, Area Sources Committee EIIP, April 2003. http://www.epa.gov/ttn/chief/eiip/techreport/volume03/index.html.

Residential and Commercial/Institutional Natural Gas and Liquefied Petroleum Gas Combustion, Volume III: Area Source Method Abstracts, Area Sources Committee EIIP, July 1999. http://www.epa.gov/ttn/chief/eiip/techreport/volume03/ng.pdf.

Energy Information Administration (EIA), U.S. Department of Energy, Washington, D.C. *Natural Gas Production & Use by Missouri* table:
http://www.eia.doe.gov/emeu/states/ngsales/ngsales_mo.html
The U.S Bureau of Census, Department of Commerce, Washington, D.C. U.S Bureau of Census American Factfinder site for residential fuel statistics:
http://factfinder.census.gov/home/saff/main.html?_lang=en. Go to Data Sets; select Census 2000 Summary File 3 (SF 3) - Sample Data and within this selection click on List all tables; scroll all the way to Table H40. House Heating Fuel. Follow the arrows, select Counties; All Counties; MA; at the top of the table is a button to Print/ Download into Excel.

EIIP Document Series – Volume III Area Sources - *Chapter 1. Introduction to Area Source Emission Inventory Development,* August 1996.
http://www.epa.gov/ttn/chief/eiip/techreport/volume03/index.html

Compilation of Air Pollution Emission Factors. Volume I: Stationary Point and Area Sources. AP-42 (Fifth Edition), U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC, January 1995.

2.20 Distillate Fuel Oil and Kerosene Combustion

2.20.1 Source Description and Emission Controls

This emission source covers air emissions from the combustion of distillate fuel oils and kerosene by the residential, commercial/institutional and industrial sectors for space heating, water heating or process heating. This source category includes small boilers, furnaces, heaters, and other heating units that are not inventoried as point sources. Residential and commercial fuel oil and kerosene combustion sectors include housing units; wholesale and retail businesses; health institutions; social and educational institutions; and federal, state and local government institutions (e.g., military installations, prisons, office buildings).

Two major categories of fuel oil are burned by combustion sources: distillate oils and residual oils. These oils are further distinguished by grade numbers, with Nos. 1 and 2 being distillate oils; Nos. 5 and 6 being residual oils; and No. 4 being either distillate oil or a mixture of distillate and residual oils. No. 6 fuel oil is sometimes referred to as Bunker C. Distillate oils are more volatile and less viscous than residual oils. They have negligible nitrogen and ash contents and usually contain less than 0.3 percent sulfur (by weight). Distillate oils are used mainly in domestic and small commercial applications, and include kerosene and diesel fuels. Being more viscous and less volatile than distillate oils, the heavier residual oils (Nos. 5 and 6) may need to be heated for ease of handling and to facilitate proper atomization. Because residual oils are produced from the residue remaining after the lighter fractions (gasoline, kerosene, and distillate oils) have been removed from the crude oil, they contain significant quantities of ash, nitrogen, and sulfur. Residual oils are used mainly in utility, industrial, and large commercial applications.

2.20.2 Emission Estimation Methodology

Activity

The area source method given in EIIP volume III was used to estimate emissions from residential, commercial/institutional, and industrial distillate fuel oil and kerosene combustion. This method relies on the number of households burning distillate fuel oil and kerosene per county, and county employment figures in the commercial/institutional and industrial sectors. The quantity of distillate fuel oil and kerosene used by the residential, commercial, and industrial sectors in Missouri was obtained from the Energy Information Administration (EIA) at the U.S. Department of Energy.

<u>Residential Sources:</u>

The sum of distillate fuel oil and kerosene burned at the state level is apportioned to the county level using U.S. Census data on households that use fuel oil or kerosene as a primary fuel. The equation is:

$$\text{County Fuel Oil use} = \text{Statewide Fuel Oil use} \times \frac{\text{County Fuel Oil burning households}}{\text{State Fuel Oil burning households}}$$

<u>Commercial/Institutional Sources:</u>

The fuel oil burned at the state level is apportioned to the county level using 2002 MERIC employment data in NAICS categories 11, and 42-92 as outlined in Section 1.3.1. The equation is:

$$\text{County Fuel Oil Use} = \text{Statewide Fuel Oil use} \times \frac{\text{NAICS 11, 42-92 employees by county}}{\text{NAICS 11, 42-92 employees by state}}$$

Industrial Sources:

The fuel oil and kerosene burned at the state level is apportioned to the county level using 2002 MERIC employment data in NAICS categories 21-33. The equation is:

$$\text{County Fuel Oil use} = \text{Statewide Fuel Oil use} \times \frac{\text{NAICS 21-33 employees by county}}{\text{NAICS 21-33 employees by state}}$$

Emission Factors

Fuel oil and kerosene combustion emission factors for VOC, NOx, CO, SO2, and PM are shown in Table 2.18-1. These were obtained from AP-42/FIRE where provided. Those emission factors not in AP-42 were determined in discussions with Pechan Associates, who is verifying and consolidating all the CenRAP states 2002 NEI submittals.

Table 2.20-1. Fuel Oil / Kerosene Combustion Emission Factors

Point SCC:		10300501/02/03	10200501/02/03
Area SCC:	**2104004000**	**2103004000**	**2102004000**
Pollutant	**Residential EF (lb/1000 Gallons)**	**Commercial EF (lb/1000Gallons)**	**Industrial EF (lb/1000 Gallons)**
VOC	0.713	0.34	0.2
NOX	18	20	20
CO	5	5	5
SO2	0.426	0.426	0.426
PM10 PRI (Total)	2.38	2.38	2.3
PM2.5 PRI (Total)	2.13	2.13	1.55
PM10 (Filterable)	1.08	1.08	1
PM2.5 (Filterable)	0.83	0.83	0.25
PM10 & 2.5 (Condensable)	1.3	1.3	1.3

The emission factor for SO2 is 142S where S = sulfur content, said to be less than 0.3% for distillate oils, is assumed to be 0.3% to be conservative.

It was assumed that kerosene emission factors are similar to distillate oil emission factors.

Temporal Adjustments for Ozone

For the 8-hour ozone NAAQS emission inventory, EPA guidance calls for CO, NOx, and VOC emissions to be reported as actual annual and actual summer weekday. Summer weekday emissions are defined as an average day's emissions for a typical summer day during the ozone season, typically defined as the months of June, July, and August. Fossil fuel consumption drops substantially during the summer months when the need for space heating is virtually zero. A seasonal activity factor is therefore needed to reflect the proportion of fuel consumption that takes place in June-August relative to annual consumption and emissions.

The best way to determine the seasonal activity factor is to obtain activity data that are specific for the location and season of interest. The most specific activity data available is Missouri monthly natural gas consumption data for 2002 for the residential, commercial, and industrial sectors obtained from the EIA and described in the *Natural Gas Combustion Section 2.17.3 Temporal Adjustments*. This same activity data was used to derive a residential, commercial/institutional, and industrial seasonal activity factor (SAF) for all the area source fossil fuel combustion calculations, which should have very close to the same proportion of fuel consumed in June-August,

Sample Calculations (Cole County)

Residential Fuel Oil and Kerosene:

Annual VOC (tons/year) = (amount of fuel oil used in Missouri per yr) X (# houses using fuel oil in county) / (# houses using fuel oil in Missouri) X (VOC emission factor) / (2000 lb/ton)

OSD VOC (lb/day) = Annual VOC (tons/year) X 2000 lb/ton X Seasonal Activity Factor / Active Days per Season

Amount of Fuel Oil Used in Missouri: 15,708 tons

Number of Houses Using Fuel Oil in Missouri: 13,893

Number of Houses Using Fuel Oil in Cole County: 40

VOC Emission Factor: 0.713 lb/ton

Activity Days Per Week: 7

Residential Seasonal Activity Factor (SAF) = 0.0655

Active Days During Ozone Season (June-August): 92

Annual VOC (tons/year) = 15,708 1000 Gallons X (40 houses/ 13,893 houses) X (0.713 lb/1000 Gallons) / 2000 lb/ton = 0.016 tons/year

OSD VOC (lb/day) = 0.016 X 2000 lb/ton X 0.0655 / 92 days = 0.023 lb/day

Commercial / Institutional Fuel Oil and Kerosene:

Annual VOC (tons/year) = (amount of Fuel Oil used in Missouri per yr) X (# Comm./Inst. employees in county) / (# Comm./Inst. employees using Fuel Oil in Missouri) X (VOC emission factor(lb/1000 Gallons)) / (2000 lb/ton)

OSD VOC (lb/day) = Annual VOC (tons/year) X 2000 lb/ton X SAF / Operating days/season

Amount of Fuel Oil Used in Missouri: 44,368 1000 Gallons

Number of Comm./Inst. Employees in Missouri: 2,063,988

Number of Comm./Inst. Employees in Cole County: 46,695

VOC Emission Factor: 0.34 lb/1000 Gallons

Activity Days Per Week: 6

Active Days During Ozone Season (June-August): 79

Commercial/Industrial Seasonal Activity Factor (SAF): 0.0950

Annual VOC (tons/year) = 44,368 1000 Gallons X (46,695 / 2,063,988) X (0.34 lb/1000 Gallons) / (2000 lb/ton) = 0.17 tons/year

OSD VOC (lb/day) = 0.17 tons/year X 2000 lb/ton X 0.0950 / 79 = 0.41 lb/day

<u>Industrial Fuel Oil and Kerosene:</u>

Annual VOC (tons/year) = (amount of Fuel Oil used in Missouri per yr) X (# Industrial employees Cole County) / (# Industrial employees in Missouri) X (VOC emission factor (lb/1000 Gallons)) / (2000 lb/ton)

OSD VOC (lb/day) = Annual VOC (tons/year) X 2000 lb/ton X SAF / Operating days/season

Amount of Fuel Oil Used in Missouri: 145,476 1000 Gallons

Number of Employees in Industrial Sector in Missouri: 462,567

Number of Employees in Industrial Sector in Cole County: 5,621

VOC Emission Factor: 0.2 lb/1000 Gallons

Industrial Seasonal Activity Factor (SAF) = 0.2010

Activity Days Per Week: 6

Active Days During Ozone Season (June-August): 79

Annual VOC (tons/year) = 145,476 1000 Gallons X (5,621 / 462,567) X (0.2 lb/1000 Gallons) / (2000 lb/ton) = 0.177 tons/year

OSD VOC (lb/day) = 0.177 tons/year X 2000 lb/ton X 0.2010 / 79 = 0.90 lb/day

2.20.3 Results

The emissions from Fuel Oil and Kerosene Combustion for the State of Missouri are as follows:

2002 Emissions from Fuel Oil and Kerosene Combustion in Missouri (Tons/Year)

	VOC	NOx	CO	SO2	PM10	PM2.5
Residential	5.5999	141.3720	39.2700	3.3458	18.6925	16.7290
Commercial	7.5425	443.6777	110.9194	9.4503	52.7976	47.2517
Industrial	14.5476	1,454.7625	363.6906	30.9864	167.2977	112.7441

Note how high the SO2 emissions are, based on the average sulfur content of 4% in Missouri coal. However, much of the coal burned in Missouri is from other states such as Wyoming, which is low sulfur coal. The average sulfur content of coal burned in Missouri should therefore be determined with greater accuracy and these emissions revised. Revised emissions should be sent to the EPA in the next round of revisions.

2.20.4 References

Energy Information Administration (EIA), U.S. Department of Energy, Washington, D.C. EIA Fuel Oil and Kerosene Sales 2002
http://www.eia.doe.gov/pub/oil_gas/petroleum/data_publications/fuel_oil_and_kerosene_sales/current/pdf/foksall.pdf

Residential Commercial/Institutional Fuel Oil Combustion, Volume III: Area Source Method Abstracts, Area Sources Committee EIIP, April 1999.

Introduction to Area Source Emission Inventory Development, Volume III: Chapter 1, Area Sources Committee EIIP, August 1996.

Compilation of Air Pollution Emission Factors. Volume I: Stationary Point and Area Sources. AP-42 (Fifth Edition), U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC, January 1995.

2.21 COAL COMBUSTION

2.21.1 Source Description and Emission Control

Coal is a complex combination of organic matter and inorganic mineral matter formed over eons from successive layers of fallen vegetation. Bituminous coals are by far the largest group and are characterized as having lower fixed carbon and higher volatile matter. This source category covers air emissions from coal combustion in the residential and commercial sectors for space heating or water heating. This category includes small boilers, furnaces, heaters, and other heating units that are not inventoried as point sources. Residential and commercial coal combustion sectors comprise housing units; wholesale and retail businesses; health institutions; social and educational institutions; and federal, state, and local government institutions. Major emissions from coal combustion are volatile organic compounds (VOC), nitrogen oxides (NOx), carbon monoxide (CO), sulfur oxides (SOx), and particulate matter (PM_{10} and $PM_{2.5}$).

2.21.2 Emission Estimation Methodology

Activity

The area source method given in EIIP volume III was used to estimate emissions from residential, commercial/institutional, and industrial coal combustion. This method relies on the number of households burning coal per county, and county employment figures in the commercial/institutional and industrial sectors. The quantity of coal used by the residential, commercial, and industrial sectors in Missouri was obtained from the Energy Information Administration (EIA) at the U.S. Department of Energy.

Residential Sources:

The coal burned at the state level is apportioned to the county level using U.S. Census data on households that use coal as a primary fuel. The equation is:

$$\text{County coal use} = \text{Statewide coal use} \times \frac{\text{County coal-burning households}}{\text{State coal-burning households}}$$

Commercial/Institutional Sources:

The coal burned at the state level is apportioned to the county level using 2002 MERIC employment data in NAICS categories 11, and 42-92 as outlined in Section 1.3.1. The equation is:

$$\text{County coal Use} = \text{Statewide coal use} \times \frac{\text{NAICS 11, 42-92 employees by county}}{\text{NAICS 11, 42-92 employees by state}}$$

Industrial Sources:

The coal burned at the state level is apportioned to the county level using 2002 MERIC employment data in NAICS categories 21-33. The equation is:

$$\text{County coal use} = \text{Statewide coal use} \times \frac{\text{NAICS 21-33 employees by county}}{\text{NAICS 21-33 employees by state}}$$

Emission Factors

Coal combustion emission factors for VOC, NOx, CO, SO2, and PM are shown in Table 2.15-1. These were obtained from AP-42/FIRE where provided. Those emission factors not in AP-42 were determined in discussions with Pechan Associates, who is verifying and consolidating all the CenRAP states 2002 NEI submittals.

Table 2.21-1. Coal Combustion Emission Factors

Point SCC:	10300214	10300208	10200202
Area SCC:	2104002000	2103002000	2102002000
Pollutant	Residential EF (lb/ton)	Commercial EF (lb/ton)	Industrial EF (lb/ton)
VOC (TNMOC)	10	1.3	0.06
NOX	9.1	9.5	22
CO	275	11	0.5
SO2	124	124	152
PM10 PRI (Total)	7.24	7.24	20.22
PM2.5 PRI (Total)	4.84	4.84	6.62
PM10 (Filterable)	6.2	6.2	18.4
PM2.5 (Filterable)	3.8	3.8	4.8
PM10 & 2.5 (Condensible)	1.04	1.04	1.82

AP-42's emission factor for sulfur is 31 S (S= Sulfur content) = 124 lb/ton (residential and commercial/institutional); and 38 S (S= Sulfur content) = 152 lb/ton (industrial). SO2 Sulfur content in Missouri averages about 4%.
http://www.eia.doe.gov/cneaf/coal/st_coal_pdf/0576q.pdf

8% Ash content is assumed based upon AP-42 and January 2000 *Mercury Speciation Stack Sampling Test Report: Meramec Unit 4* that was conducted for the EPA's Information Collection Request (ICR) to characterize mercury emissions from coal-fired power plants in the United States.

Temporal Adjustments for Ozone

For the 8-hour ozone NAAQS emission inventory, EPA guidance calls for CO, NOx, and VOC emissions to be reported as actual annual and actual summer weekday. Summer weekday emissions are defined as an average day's emissions for a typical summer day during the ozone season, typically defined as the months of June, July, and August. Fossil fuel consumption drops substantially during the summer months when the need for space heating is virtually zero. A seasonal activity factor is therefore needed to reflect the proportion of fuel consumption that takes place in June-August relative to annual consumption and emissions.

The best way to determine the seasonal activity factor is to obtain activity data that are specific for the location and season of interest. The most specific activity data available is Missouri monthly natural gas consumption data for 2002 for the residential, commercial, and industrial sectors obtained from the EIA and described in the *Natural Gas Combustion Section 2.17.3 Temporal Adjustments*. This same activity data was used to derive a residential, commercial/institutional, and industrial seasonal activity factor (SAF) for all the area source fossil fuel combustion calculations, which should have very close to the same proportion of fuel consumed in June-August.

Sample Calculations – Cole County

Residential Coal:

Annual VOC (tons/year) = (amount of coal used in Missouri per yr) X ((# houses using coal in county) / (# houses using coal in Missouri)) X (VOC emission factor(lb/ton)) / (2000 lb/ton)

OSD VOC (lb) = (amount of coal used in Missouri per yr) X (# houses using coal in county) / (# houses using coal in Missouri) X (VOC emission factor) X Seasonal Activity Factor / Active Days per Season

Amount of Coal Used in Missouri: 19,000 tons

Number of Houses Using Coal in Missouri: 170

Number of Houses Using Coal in Cole County: 0

VOC Emission Factor: 10 lb/ton

Activity Days Per Week: 7

Residential Seasonal Activity Factor (SAF) = 0.0655

Active Days During Ozone Season (June-August): 92

Annual VOC = 19,000 tons X (0 houses/ 170 houses) X (10 lb/ton) / (2000 lb/ton)
= 0 tons/year

OSD VOC = 19,000 tons X (0 houses/ 170 houses) X (10 lb/ton) X 0.0655 (proportion of fuel consumed in June-August) / 92 days = 0 lb/day

Commercial / Institutional Coal:

Annual VOC (tons/year) = (amount of coal used in Missouri per yr) X (# employees using coal in county) / (# employees using coal in Missouri) X (VOC emission factor(lb/ton)) / (2000 lb/ton)

OSD VOC (lb) = (amount of coal used in Missouri per yr) X (# employees using coal in county) / (# employees using coal in Missouri) X (VOC emission factor) X (seasonal activity factor) / (active days during June – August)

Amount of Coal Used in Missouri: 147,794.07

Number of Employees in Commercial/Institutional Sector in Missouri: 2,063,988

Number of Employees in Commercial/Institutional Sector in Cole County: 46,695

VOC Emission Factor: 1.3 lb/ton

Commercial/Institutional Seasonal Activity Factor (SAF) = 0.0950

Activity Days Per Week: 6

Active Days During Ozone Season (June-August): 79

Annual VOC = 147,794.07 tons X (46,695 / 2,063,988) X (1.3 lb/ton) / (2000 lb/ton)
= 2.17 tons/year

OSD VOC = Annual VOC X 2000 lb/ton X (0.0950 (proportion of fuel consumed in June-August)) / 79 days = 5.23 lb/day

<u>Industrial Coal:</u>

Annual VOC (tons/year) = (amount of coal used in Missouri per yr) X (# employees using coal in county) / (# employees using coal in Missouri) X (VOC emission factor(lb/ton)) / (2000 lb/ton)

OSD VOC (lb) = (amount of coal used in Missouri per yr) X (# employees using coal in county) / (# employees using coal in Missouri) X (VOC emission factor) X (seasonal activity factor) / (active days during June – August)

Amount of Coal Used in Missouri: 429,959 tons

Number of Employees in Industrial Sector in Missouri: 462,567

Number of Employees in Industrial Sector in Cole County: 5,621

VOC Emission Factor: 0.06 lb/ton

Industrial Seasonal Activity Factor (SAF) = 0.2010

Activity Days Per Week: 6

Active Days During Ozone Season (June-August): 79

Annual VOC = 429,959 tons X (5,621 / 462,567) X (0.06 lb/ton) / 2000 lb/ton

= 0.16 tons/year

OSD VOC = 429,959 tons X (5,621 / 462,567) X (0.06 lb/ton) / X (0.2010) / 79
= 0.80 lb/day

2.21.3 Results

The emissions from Coal Combustion for the State of Missouri are as follows:

2002 Emissions from Coal Combustion in Missouri (Tons/Year)

	VOC	NOx	CO	SO2	PM10	PM2.5
Residential	95.00	86.45	2,612.5	1,178.0	68.78	45.98
Commercial	96.07	702.02	812.87	9,163.2	535.01	357.66
Industrial	12.90	4,729.55	107.49	32,676.87	4,346.88	1,423.16

Note how high the SO2 emissions are, based on the average sulfur content of 4% in Missouri coal. However, much of the coal burned in Missouri is from other states such as Wyoming, which is low sulfur coal. The average sulfur content of coal burned in Missouri should therefore be determined with greater accuracy and these emissions revised. Revised emissions should be sent to the EPA in the next round of revisions.

2.21.4 References

Energy Information Administration (EIA), U.S. Department of Energy, Washington, D.C.
EIA 2002 Coal Consumption: http://www.eia.doe.gov/cneaf/coal/page/acr/acr.pdf

The U.S Bureau of Census, Department of Commerce, Washington, D.C.

P:\APCP\Tech Support\Users\Mollie Freebairn\NEI\2002 NEI Residential Energy Consumption in Missouri.xls

National Oceanographic and Atmospheric Administration (NOAA).

Residential Commercial/Institutional Coal Combustion, Volume III: Area Source Method Abstracts, Area Sources Committee EIIP, April 1999.

Introduction to Area Source Emission Inventory Development, Volume III: Chapter 1, Area Sources Committee EIIP, August 1996.

Compilation of Air Pollution Emission Factors. Volume I: Stationary Point and Area Sources. AP-42 (Fifth Edition), U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC, January 1995.

East-West Gateway Coordinating Council, St. Louis City, MO.

The 2002 NEI Area Source Fuel Combustion spreadsheets containing the final revised emission factors and other parameters agreed to with Pechan are located on the APCP P:/Drive at 2002 NEI Area Source Fuel Combustion_RevPMData.xls

Emission factor revisions were discussed at length in e-mail correspondence between Mollie Freebairn, APCP and Randy Strait, Pechan Associates, on 9/13, 9/14, 9/16, 9/17, and 9/18/2004 and are on file at the APCP.

EIA State Coal Profile: Missouri http://www.eia.doe.gov/cneaf/coal/st_coal_pdf/0576q.pdf

2.22 Wood Combustion – Residential

In the 1999 NEI for Missouri, Residential Wood Burning was the second highest area source category for criteria pollutant emissions overall, primarily CO, VOC, and PM10 and PM2.5, second only to unpaved road fugitive dust emissions. Its ranking was similar in other states. These findings have led to a number of studies and surveys around the United States to improve and update activity data and emission factors for residential wood burning. While it was not possible to conduct a statewide survey here in Missouri to determine residential wood burning usage patterns, there is good information available from the Energy Information Administration, 2000 U.S. Census, and other studies referenced below, that was carefully reviewed and incorporated into the somewhat complex method described below.

2.22.1 Source Description and Emission Controls

This area source category of residential wood combustion is defined as wood burning that takes place primarily in woodstoves and fireplaces. Residential wood burning takes place either as a necessary source of heat or for aesthetics. Fireplaces can be divided into 2 broad categories: (1) masonry (generally brick and/or stone, assembled on site, and integral to a structure) and (2) factory-built (usually metal, installed on site as a package with appropriate ductwork). Woodstoves are commonly used in residences as space heaters. They are used both as the primary source of residential heat and to supplement conventional heating systems. There are seven different residential wood combustion source categories:

y **FIREPLACES**
x 2104008001 Without Inserts
x 2104008002 With Inserts; Non-EPA Certified
x 2104008003 With Inserts; Non-Catalytic, EPA Certified
x 2104008004 With Inserts; Catalytic, EPA Certified
y **WOODSTOVES**
x 2104008010 Non-EPA Certified
x 2104008030 Catalytic, EPA Certified
x 2104008050 Non-Catalytic, EPA Certified

Pollutants emitted from residential wood combustion include particulate mater (PM), volatile organic compounds (VOC), nitrogen oxides (NOx), carbon monoxide (CO), and hazardous air pollutants (HAP). Controls for this category may use new technology woodstoves, improvements in wood burning performance, use of "no burn" periods, public awareness and educational programs, replacement or installation of gas-burning equipment in fireplaces, and total banning of burning.

2.22.2 Emission Estimation Methodology

Activity

The Energy Information Administration (EIA) reports Residential Wood Consumption in Missouri for 1960 to 2000. According to the EIA, in 1987 a total of 907,000 cords was burned in Missouri. The U.S. Forest Service study reports that in 1987, a total of 924,154 cords of wood were produced in Missouri. These figures agree well, since somewhat more wood should have been produced than was consumed.

The EIA estimate for 2000 residential wood consumption in Missouri is 484,000 cords, the latest year for which figures are available. To project an estimate for 2002 residential wood consumption, the EIA data for natural gas consumption in Missouri's residential sector for 2000, 2001, and 2002 are employed. Residential wood consumption was projected by assuming that it was proportional to that of natural gas in Missouri:

Year	Residential Natural Gas (Million Cu. Ft.)	Residential Fuelwood (Cords)
2000	115,353	484,000
2001	116,188	487,504
2002	115,721	485,544

Census 2000 provides a table of number of occupied housing units and house heating fuels for each county in Missouri for 2000. Across Missouri overall about 4% of households used wood, in some counties the average was as high as 34%.

Separate wood consumption estimates for fireplaces with inserts, fireplaces without inserts, non-EPA certified woodstoves, catalytic & noncatalytic EPA-certified woodstoves are made to account for different usage patterns (climate zones; urban vs. rural), and different emission factors, which were obtained from US Census, EIA, and EPA. Primary Wood-Burning Heating Equipment from *American Housing Survey for the United States in 2001* is as follows:

Stoves…………………………	1,131,000	84.4%
Fireplaces with inserts…………..	145,000	10.8
Fireplaces without inserts…………	64,000	4.8
Total…………………………..	1,340,000	100.0

These proportions were applied to the total number of households burning wood as their main house heating fuel to obtain the number of stoves and fireplaces in each Missouri county. Similar proportions are given in the *EIA 2001 Residential Energy Consumption Survey, Table HC3-1b. Space Heating by Climate Zone, Percent of U.S. Households*, where for Missouri's climate zone, heating stoves comprise 78% of main wood-burning heating equipment and 22% is classified as "other".

92% of the woodstoves are non-EPA certified, 5.7% are EPA certified non-catalytic, and 2.3 percent are EPA-certified catalytic according to *Documentation for Version 2 of the 1999 NEI for Criteria Pollutants- Area Sources*. These figures were used to allocate primary heating with wood to fireplaces and stoves.

The average number of cords burned per main wood-burning unit per year is:

485,544 cords / 77,666 units = 6.25 cords/unit/year

Consulting with people who have used wood as a primary source of fuel, 4 to 6 cords is in fact about what it takes to heat a home for the winter, more for a larger home.

10.1% of all households burn wood as a secondary source of fuel (from Missouri's climate zone in the *EIA 2001 Residential Energy Consumption Survey* cited above.) These households range from those who burn a substantial quantity of wood to those who use it for aesthetic purposes. 10% will be assumed to be the households that burn purely for aesthetic purposes, until more guidance becomes available. The amount burned for aesthetics is estimated over and above that obtained from the EIA, as described in *Documentation for Version 2 of the 1999 NEI for Criteria Pollutants- Area Sources*, cited above: "We have the total cords of wood consumed by the residential section for 1997 from the EIA. This figure does not include consumption for aesthetics…." The average number of cords burned in fireplaces for aesthetic purposes is 0.069 cords/unit/year.

The U.S. Forest Service's 1987 study found that oak and hickory were the principal fuelwood species in Missouri, accounting for 60% and 9% of the total harvested, respectively. Both oak and hickory hardwoods have a density conversion factor of 39.9. One cord of wood is equal to about 79 cubic feet of solid wood.

Emission Factors

Residential wood combustion emission factors are given in *DOCUMENTATION FOR THE FINAL 1999 NATIONAL EMISSIONS INVENTORY (VERSION 3.0) FOR CRITERIA AIR POLLUTANTS AND AMMONIA AREA SOURCES*, Appendix B.

Table B-1. Criteria Pollutant Emission Factors For Residential Wood Combustion, lb/ton

SCC		VOC	NOX	CO	SO2	PM10	PM2.5
2104008001	Fireplaces	229	2.6	64.1	0.4	11.8	11.8
2104008002	Fireplaces: Inserts; non-EPA certified	53	2.8	230.8	0.4	30.6	30.6
2104008003	Fireplaces: Inserts; non-catalytic, EPA certified	12		140.8	0.4	19.6	19.6
2104008004	Fireplaces: Inserts; catalytic, EPA certified	15	2	104.4	0.4	20.4	20.4
2104008010	Woodstoves: General	53	2.8	230.8	0.4	30.6	30.6
2104008030	Catalytic Woodstoves: General	15	2	104.4	0.4	20.4	20.4
2104008050	Non-catalytic Woodstoves: General	12		140.8	0.4	19.6	19.6

Assumptions

It was assumed that there was not significant industrial and commercial wood combustion. The calculations were based strictly on residential consumption data. Temporal adjustments for the ozone season were not made although they perhaps should be since VOC emissions are so high. This would entail a revision to our 2002 NEI submittal to the EPA.

Sample Calculation (Cole County)

SCC - 2104008010 Woodstoves: General - Annual VOC (tons/year) = (number of households in Cole Country heating with wood) X (% of households using woodstoves) X (% of wood stoves that are non-EPA certified) X (average number of cords/household/year) X (volume of a cord of wood) X (density of a cord of wood) / (2000 lb wood/ton) X (VOC emission factor) / (2000 lb emissions/ton)

Number of Houses Burning Wood in Cole County: 335

% of Households Burning Wood that have Woodstoves: 84%

% of Woodstoves that are non-EPA Certified: 92%

Average number of cords/household/year: 6.25

Volume of a cord of wood: 79 cu. ft./cord

Density of a cord of wood: 39.9 lb/cu.ft

VOC Emission Factor: 53 lb/ton

Woodstoves: General - Annual VOC (tons/year) =
335 households X 0.844 X 0.92 X 6.25 cords/household/year X 79 cu. ft./cord X 39.9 lb/cu.ft / 2000 lb/ton X 53 lb VOC/ton / 2000 lb/ton = 68 tons VOC/year

2.22.3 Results

The emissions from Residential Wood Combustion for the State of Missouri are as follows:

2002 Emissions from Residential Wood Combustion in Missouri (Tons/Year)

	VOC	NOx	CO	SO2	PM10	PM2.5
2104008001 Fireplaces	6,938	79	3,884	12	715	715
2104008002 Fireplaces: Inserts; non-EPA certified	2,190	116	9,537	17	1,264	1,264
2104008010 Woodstoves: General	15,746	832	68,570	119	9,091	9,091
2104008030 Catalytic Woodstoves: General	111	15	775	3	152	152

2104008050 Non-catalytic Woodstoves: General	221	0	2,592	7	361	361
2002 EMISSIONS - TOTAL ALL POLLUTANTS – 123,347 TONS	**25,206**	**1,042**	**85,358**	**158**	**11,583**	**11,583**
1999 EMISSIONS – TOTAL ALL POLLUTANTS – 206,454 TONS	**93,211**	**1,058**	**102,817**	**137**	**9,231**	**9,231**

2.22.4 References

- EIIP Document Series – Volume III Area Sources - Chapter 1. Introduction to Area Source Emission Inventory Development, August 1996. http://www.epa.gov/ttn/chief/eiip/techreport/volume03/index.html
- Emission Inventory Improvement Program (EIIP), Document Series - Volume III, Area Sources, Chapter 2 - Residential Wood Combustion, April 2001. http://www.epa.gov/ttn/chief/eiip/techreport/volume03/index.html.
- Energy Information Administration (EIA), U.S. Department of Energy, Washington, D.C. http://www.eia.doe.gov/emeu/states/sep_use/res/use_res_mo.html, also in our spreadsheets at ..\Excell\EIA Residential Energy Consumption in Missouri.xls. Natural gas consumption: http://www.eia.doe.gov/emeu/states/ngsales/ngsales_mo.html.
- EIA 2001 Residential Energy Consumption Survey, Table HC3-1b. Space Heating by Climate Zone, Percent of U.S. Households, 2001 – Preliminary Data http://www.eia.doe.gov/emeu/recs/recs2001/detail_tables.html
- USDA Forest Service Residential Fuelwood Production and Sources from Roundwood in Missouri, 1987. http://www.ncrs.fs.fed.us/pubs/rb/rb_nc132.pdf.)
- The U.S Bureau of Census, Department of Commerce, Washington, D.C. U.S Bureau of Census American Factfinder site for residential fuel statistics is at http://factfinder.census.gov/servlet/BasicFactsServlet, also see http://factfinder.census.gov/home/saff/main.html?_lang=en. Go to Data Sets; select Census 2000 Summary File 3 (SF 3) - Sample Data and within this selection click on List all tables; scroll all the way to Table H40. House Heating Fuel. Follow the arrows, select Counties; All Counties; MA; Print/ Download into Excel.
- American Housing Survey for the United States in 2001 Table 2-21 Housing Costs by Selected Characteristics – Occupied Units - Consistent with the 1990 Census.
- Four Winters' Worth of Residential Fuelwood Use 1979-80 1981-82 1984-85 1987-88, Missouri Department of Conservation, 1988.
- USDA Forest Service Residential Fuelwood Production and Sources from Roundwood in Missouri, 1987. http://www.ncrs.fs.fed.us/pubs/rb/rb_nc132.pdf
- Compilation of Air Pollution Emission Factors. Volume I: Stationary Point and Area Sources. AP-42 (Fifth Edition), U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC, January 1995.

2.23 Traffic Markings

2.23.1 Source Description and Emissions Control

Traffic marking operation consists of marking of highway center, edge stripes, and directional markings and painting on other paved and unpaved surfaces, such as markings in parking lots. Materials used for traffic markings include solvent-based paints, water-bared paints, thermoplastics, preformed tapes, field-reacted materials, and permanent markers. Solvent-based formulations of alkyd resins or chlorinated rubber resins are the most commonly used traffic paints. This inventory report focuses on applications of traffic paints that emit a significant quantity of volatile organic compounds (VOC).

VOC emissions result from the evaporation of organic solvents during and shortly after the application of the marking paint. Three types emit VOC in appreciable amount are: (a) Non-aerosol traffic paint, (b) Aerosol marking paint, and (c) Performed tapes applied to adhesive primer. VOC emissions can also result from cleaning the striping equipment. Because the use of organic solvents in traffic marking is the primary source of emissions, control techniques for this source category involve either product substitution or product reformulation. Alternative formulations include low-solvent-content coatings, water-based coatings, and plastic-based coatings.

2.23.2 Emission Estimation Methodology

Activity Level

The Missouri Department of Transportation (MODOT) keeps records of amount of paint used for traffic coatings in 10 Districts. Since MODOT does not keep records of paint for each county, population figures were used to estimate how much paint was used for each county.

Emission Factor

Based on MODOT information the VOC emission factors for the paint used in 2002 are as follows:

TYPE of Paint	VOC Content (lb/gallon)
White Waterborne	.81
Yellow Waterborne	.81
White Acrylic Copolymer	1.11
Yellow Acrylic Copolymer	1.05
White Epoxy	0
Yellow Epoxy	0

Assumptions

According to a national-level survey of traffic coating end users, it was assumed that 5% of traffic coatings in Missouri was done by agencies other than the Department of Transportation.

Sample Calculation (Cole County)

VOC Emissions (tons/year) = (Population Cole County/Population of District 5) X(VOC emissions for District 5) / 2000 lb/ton

VOC Emissions for District 5 (lb)= Amount of Paint Used (gallons) X VOC Content of Paint (lb/gal) X 1.05 (to account for 5% paint used by other agencies)

Population of Cole County: 71894

Population of District 5: 461578

Gallons of White Waterborne Paint Used in District 5: 37931 gal.

Gallons of Yellow Waterborne Paint Used in District 5: 69653 gal.

Gallons of White Acrylic Copolymer Paint Used in District 5: 102 gal.

Gallons of Yellow Acrylic Copolymer Paint Used in District 5: 106 gal.

Gallons of White Epoxy Paint Used in District 5: 0 gal.

Gallons of Yellow Epoxy Paint Used in District 5: 0 gal.

Activity Days Per Week: 5

VOC Emissions (ton/year) = (71894/461578) X [(37931 X .81) + (69653 X .81) + (102 X 1.11) + (106 X 1.05) + (0 X 0) + (0 X 0)] X 1.05 / 2000 (lb/ton) = 7.144 ton/year

2.23.3 Results

Total VOC emissions from traffic marking for the State of Missouri is 465.7 tons/year.

2.23.4 References

- *Traffic Markings*, Volume III: Chapter 14, Final Report, Area Sources Committee EIIP, May1997.
- *Introduction to Area Source Emission Inventory Development*, Volume III: Chapter 1, Area Sources Committee EIIP, August 1996.
- *Compilation of Air Pollution Emission Factors*. Volume I: Stationary Point and Area Sources. AP-42 (Fifth Edition), U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, NC, January 1995.

- United States Bureau of Census, Department of Commerce, Washington, D.C.
- Customer Service Center, Department of Transportation, Jefferson City, MO.

2.24 Commercial Marine Vessels

2.24.1 Source Description and Emission Control

Emissions from commercial marine vessels were calculated based on the tonnage of cargo moved by ships along the Missouri and Mississippi Rivers through the port of Fort Benton (Kansas City area) and the port of Metropolitan St. Louis in Missouri. This tonnage was taken from the "Waterborne Commerce of the United States - Part 2, Waterways & Harbors, Gulf Coast, Mississippi River System and Antilles" pages 17 & 38 (1).

2.24.2 Emission Estimation Methodology

Activity Level

The most recent figures for tonnage totals are from the year 2001. For the purposes of this report it was assumed that the tonnage for inventory year 2002 would be the same.

The equations used in the calculations were taken from Commercial Marine Emissions Inventory for EPA Category 2 and 3 Compression Ignition Marine Engines in the United States Continental and Inland Waterways (2). The equations are summarized below.

First, annual cargo movement in ton-miles was calculated by multiplying the number of tons shipped in 2001 along the Mississippi River and Missouri River through ports of Fort Benton and St. Louis City, Missouri, by the length of the portion of the Mississippi River and Missouri Rivers running through each individual county.

$$C = L \times T$$

Where:

C = Annual cargo movement (ton-miles)
L = Length of Mississippi & Missouri rivers through each county (miles)
T = Total amount of cargo shipped through each county (short tons)

Emissions per ton-mile were calculated by dividing the product of the deadweight tonnage, cargo capacity factor, and average vehicle speed. Deadweight tonnage is a measurement of the total contents of a ship, including cargo, fuel, crew, passengers, food, and water aside from boiler water. The cargo capacity factor is applied as a correction because ships do not typically operate fully loaded with cargo.

$$E_{TM} = E_{\mathbf{d}} \div (DWT \times CCF \times V \times 24)$$

Where:

E_{TM} = Emissions per ton-mile (lbs/ton-mile)
E_d = Emissions per day per ship from Method A (lbs/day/ship)
DWT = Average dead weight tonnage per ship (tons/ship)
CCF = Cargo capacity factor
V = Average speed of vessel across duty cycle adjusted for max. BHP (miles/hour)
24 = Hours per day to convert ship speed to ship miles per day

Emissions per year were calculated by multiplying the results from the previous equations.

$$E_Y = E_{TM} \times C$$

Where:

E_Y = Emissions per year (lb/year)
E_{TM} = Emissions per ton-mile (lbs/ton-mile)
C = Annual cargo movement (ton-miles)

The total tonnage of cargo shipped along the Mississippi River through the port of St. Louis City, Missouri, in 2001 was **34,432,000** tons. The total tonnage of cargo shipped along the Missouri River through the port of Fort Benton was **9,295,000** tons. As previously mentioned, it was assumed that the tonnages for the year 2002 would be the same. This data was obtained from the U.S. Army Corps of Engineers Waterborne Commerce Statistics Center (1).

Emission Factors

From reference 1, the following values were obtained:

Emission Factors
Avg NOx emissions per day per ship on inland rivers: 641.92 lbs per day-cargo-ship
Avg VOC , 21.70 lbs per day-cargo-ship
Cargo capacity of ships on inland rivers: 0.6
Avg deadweight tonnage per ship: 15,454 short tons
Avg speed of vessels on inland rivers: 8.18 mph

Assumptions

Emissions were apportioned to the county level based on the percent of the Mississippi River and Missouri River flowing adjacent to/through each county. It was assumed that 50% of emissions from Mississippi River would be accounted for in Illinois' inventory and the other 50% of emissions would go to Missouri's inventory (the same holds true for Platte County, whereas 50% of emissions are assumed to be accounted for in Kansas). Using the USGS National Map Viewer, the length of the Missouri & Mississippi Rivers running through the entire state was measured and recorded along with the individual lengths within each county. Maps of each county river length are attached to this report.

There is no reference that asserts the seasonal or temporal variation for this activity. Therefore, it was assumed that activity does not vary throughout the year and occurs seven days per week.

Sample Calculation (Jefferson County)

2002 NOx Emissions from Commercial Marine Vessels in Jefferson County

Cargo movement in 2002 = (Length of river through Jefferson County) x (Total tons shipped through Port of St. Louis in 2001)

= (**21.32** miles) x (**34,432,000** tons)

= **734,090,240** ton-miles

Emissions per ton-mile = (Emissions/day-ship)/[(Avg. deadweight tonnage) x (cargo capacity factor) x (Avg. speed)**]**

= (**641.92** lbs/NOx/day-ship) / [(**15,454** tons/ship) x (**0.6**) x (**8.18** miles/hr) x (24 hrs/1 day)]

= **3.53×10^{-4}** lbs NOx/ton-mile

2002 annual emissions for both sides of the Mississippi River running through Jefferson County

= (Ton-miles per year) x (Emissions per ton-mile)

= (**734,090,240** ton-miles) x (**3.53×10^{-4}** lbs/ton-mile) x (1 ton/2,000 lbs)

= **129.43** tons NOx/yr

2002 Jefferson Co. emissions = (total Mississippi River emissions) x (Percent of emissions occurring on Missouri side)

= **129.43** tons NOx/yr) x 0.50

= **64.72** tons NOx/yr

2.24.3 Results

The emissions for the State of Missouri from Commercial Marine Vessels are 74.6 ton/year VOC, 1979.2 tons/year NOx, and 184.48 tons/year PM10.

2.24.4 References

- *"Tonnage for Selected U.S. Ports in 1999" table from U.S. Army Corps of Engineers Waterborne Commerce Statistics Center, "Waterborne Commerce of the United States - Part 2, Waterways & Harbors, Gulf Coast, Mississippi River System and Antilles". (http://www.wrsc.usace.army.mil/ndc/portsname.htm)*
- *"Commercial Marine Emissions Inventory for EPA Category 2 and 3 Compression Ignition Marine Engines in the United States Continental and Inland Waterways," US EPA, EPA 420-R-98-020, August 1998. (http://www.epa.gov/otaq/regs/nonroad/marine/ci/fr/r98020.pdf)*
- *USGS National Map Viewer (http://nmviewogc.cr.usgs.gov/viewer.htm*)

1. “Tonnage for Selected U.S. Ports in 1999” table from U.S. Army Corps of Engineers Waterborne Commerce Statistics Center, *“Waterborne Commerce of the United States - Part 2, Waterways & Harbors, Gulf Coast, Mississippi River System and Antilles”*. (http://www.wrsc.usace.army.mil/ndc/portsname.htm)

2. *“Commercial Marine Emissions Inventory for EPA Category 2 and 3 Compression Ignition Marine Engines in the United States Continental and Inland Waterways*,” US EPA, EPA 420-R-98-020, August 1998. (http://www.epa.gov/otaq/regs/nonroad/marine/ci/fr/r98020.pdf)

3. USGS National Map Viewer (http://nmviewogc.cr.usgs.gov/viewer.htm)