Particulate Matter Emissions

"Particulate matter" (PM) is the general term used to describe solid particles and liquid droplets found in the air. The composition and size of these airborne particles and droplets vary. Some particles are large enough to be seen as dust or dirt, while others are so small they can only be seen using a powerful microscope. Two size ranges, known as PM_{10} and $PM_{2.5}$, are widely monitored, both at major emissions sources and in ambient air. PM_{10} includes particles that have aerodynamic diameters less than or equal to 10 microns (µm), approximately equal to one-seventh the diameter of human hair. $PM_{2.5}$ is the subset of PM_{10} particles that have aerodynamic diameters less than or equal to 2.5 µm.

Particles within the two size ranges behave differently in the atmosphere. $PM_{2.5}$, or fine particles, can remain airborne for long periods and travel hundreds of miles. Coarse particles, or the subset of PM_{10} that is larger than 2.5 µm, do not remain airborne as long and their spatial impact is typically limited because they tend to deposit on the ground downwind of emissions sources. Larger coarse particles are not readily transported across urban or broader areas because they are generally too large to remain suspended in air and they tend to be removed easily on contact with surfaces. In short, as the particle size increases, the amount of time the particles remain airborne decreases. The PM Concentrations indicator describes the various ways PM can harm human health and the environment.

PM can be emitted directly or formed in the atmosphere. "Primary" particles are those released directly to the atmosphere. These include dust from roads and black and/or elemental carbon from combustion sources. In general, coarse PM is composed largely of primary particles. "Secondary" particles, on the other hand, are formed in the atmosphere from chemical reactions involving primary gaseous emissions. Thus, these particles can form at locations distant from the sources that release the precursor gases. Examples include sulfates formed from sulfur dioxide emissions from power plants and industrial facilities and nitrates formed from nitrogen oxides released from power plants, mobile sources, and other combustion sources. Unlike coarse PM, a much greater portion of fine PM ($PM_{2.5}$) contains secondary particles.

This indicator presents trends in annual average primary PM emissions data tracked by the National Emissions Inventory (NEI). The NEI tracks emissions data, both measured and estimated, for primary particles only and therefore may only be representative of a small fraction of all emissions that serve to form $PM_{2.5}$. Because secondary particles are not released directly from stacks, the NEI instead tracks the precursors that contribute to formation of secondary particles. These precursors include nitrogen oxides, sulfur dioxide, ammonia, and other gases (e.g., particle-producing organic gases), some of which are addressed in separate indicators (the Nitrogen Oxides Emissions indicator; the Sulfur Dioxide Emissions indicator). As noted above, particles formed through secondary processes are not included in this indicator.

Primary emissions of PM can exist as solid or liquid matter (the "filterable" portion) or as gases (the "condensable" portion). Data for the condensable portion exist only for the years 1999 to 2008. To allow for a valid comparison of emissions trends from 1990 to 2008, only data for the filterable portion of PM_{10} and $PM_{2.5}$ are included in the trend graphs. Condensables are, however, included in the pie charts shown in Exhibits 2 and 5.

All emissions data presented in this indicator are taken from the NEI. Primary particulate emissions data are presented for the traditionally inventoried anthropogenic source categories: (1) "Fuel

combustion," which includes emissions from coal-, gas-, and oil-fired power plants and industrial, commercial, and institutional sources, as well as residential heaters and boilers; (2) "Other industrial processes," which includes chemical production, petroleum refining, metals production, and processes other than fuel combustion; (3) "On-road vehicles," which includes cars, trucks, buses, and motorcycles; and (4) "Nonroad vehicles and engines," such as farm and construction equipment, lawnmowers, chainsaws, boats, ships, snowmobiles, and aircraft. For 2008 only, this indicator includes a comparison of these anthropogenic sources with emissions from miscellaneous and biogenic sources, such as agriculture and forestry, wildfires and managed burning, and fugitive dust from paved and unpaved roads. Biogenic emissions were estimated using the Biogenic Emissions Inventory System Model, Version 3.14, with data from the Biogenic Emissions Landcover Database, Version 3, and 2008 annual meteorological data. The NEI also documents estimates of primary emissions from fugitive dust and miscellaneous sources.

The NEI is a composite of data from many different sources, with PM data coming primarily from EPA models as well as from state, tribal, and local air quality management agencies. Different data sources use different data collection methods, and many of the emissions data are based on estimates rather than actual measurements. For mobile sources, the data are based on mobile source models for on-road and nonroad vehicles, often using state-supplied model inputs (U.S. EPA, 2013a). Emissions from wildfires in 2008 come primarily from an estimation process that bases fire activity and location on satellite detection (U.S. EPA, 2013a). For most fuel combustion sources and industrial sources, emissions are from the state, local, and tribal air quality management agencies and are estimated using emission factors.

NEI data have been compiled since 1990 and cover all 50 states and their counties, D.C., the U.S. territories of Puerto Rico and Virgin Islands, and some of the territories of federally recognized American Indian nations. Data are presented for 1990, 1996, 1999, 2002, 2005, and 2008. With the exception of 1993, the NEI data are published on a triennial cycle, thus an annual trend is not readily available.

What the Data Show

Primary PM_{10} Emissions Trends

Estimated primary PM_{10} emissions from anthropogenic sources decreased 31 percent nationally between 1990 and 2008 (Exhibit 1). Of these sources, those in the fuel combustion category saw the largest absolute and relative decrease in emissions (824,000 tons; 69 percent). Primary PM_{10} emissions from the group of sources including miscellaneous and natural sources and fugitive dust were estimated to account for 89 percent of total primary PM_{10} emissions (including condensables from stationary and mobile sources) in 2008, the majority of which was attributable to fugitive dust from roads (Exhibit 2).

Changes in estimated primary anthropogenic PM_{10} emissions from 1990 to 2008 varied widely among EPA Regions (Exhibit 3), with decreasing emissions over this time frame observed in eight Regions and increases observed in Regions 8 and 9.

Primary $PM_{2.5}$ Emissions Trends

Estimated primary $PM_{2.5}$ emissions from anthropogenic sources decreased 51 percent nationally between 1990 and 2008 (Exhibit 4). The largest absolute and relative decline in $PM_{2.5}$ was seen in the fuel combustion source category (692,000 tons; 76 percent). Primary emissions from the group of sources including miscellaneous and natural sources and fugitive dust were estimated to account for 74 percent of the total $PM_{2.5}$ emissions (including condensables from stationary and mobile

sources) nationally in 2008 (Exhibit 5).

Primary anthropogenic $PM_{2.5}$ emissions decreased in all ten EPA Regions from 1990 to 2008, with percent reductions ranging from 19 percent (Region 8) to 78 percent (Region 1) (Exhibit 6).

Limitations

- PM emissions estimates through the NEI are provided only for the triennial NEI years starting with 1990 and continuing through 2008, with the exception of 1993.
- Because the emissions indicators focus on sources of anthropogenic origin, PM emissions from miscellaneous sources (e.g., wildfires) are not included in the trend line. Details on emissions from these sources can be found by downloading NEI inventory data for the "nonpoint sector" (http://www.epa.gov/ttn/chief/eiinformation.html).
- The emissions data for PM are largely based on estimates that employ emission factors generated from empirical and engineering studies, rather than on actual measurements of PM emissions. Although these estimates are generated using well-established approaches, including extensively reviewed mobile source models, the estimates have uncertainties inherent in the emission factors and emissions models used to represent sources for which emissions have not been directly measured.
- The methodology for estimating emissions is continually reviewed and is subject to revision. Trend data prior to these revisions must be considered in the context of those changes.
- The indicator tracks primary PM emissions. Particles that form in the air through secondary processes are not included in this indicator, but are considered in the PM Concentrations indicator.
- Not all states and local air quality management agencies provide the same data or level of detail for a given year.
- NEI emissions from on-road mobile sources prior to 2002 were estimated using the Mobile Source Emissions Factor Model (MOBILE), and 2002, 2005, and 2008 emissions for this source category were estimated using the MOtor Vehicle Emissions Simulator (MOVES) model. Thus, the change in model is reflected as part of the trend shown.

Data Sources

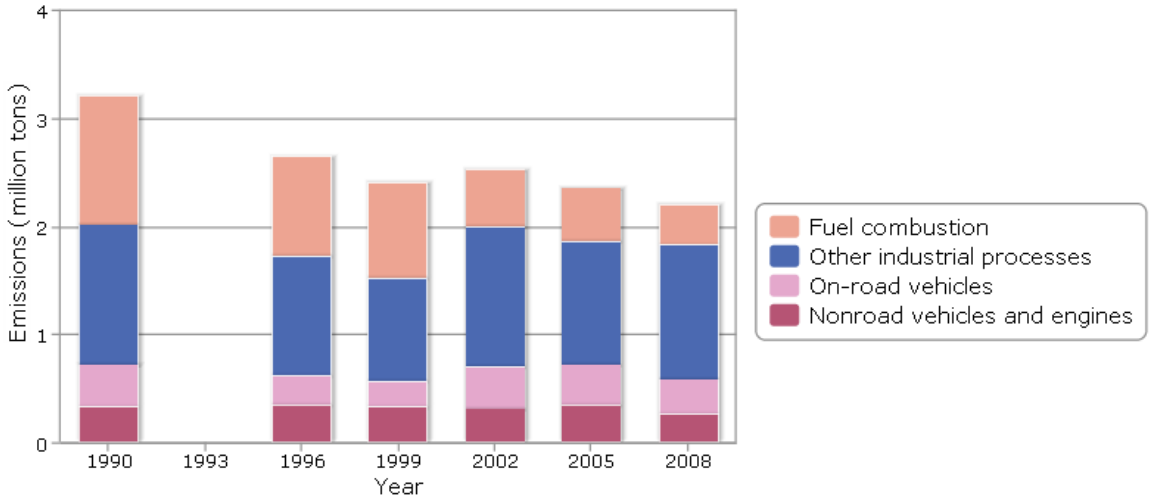
Summary data in this indicator were provided by EPA's Office of Air Quality Planning and Standards, based on biogenic and anthropogenic particulate matter emissions data in the NEI. The most recent data are taken from Version 3.0 of the 2008 NEI (U.S. EPA, 2013b). These and earlier emissions data can be accessed from EPA's emission inventory website (http://www.epa.gov/ttn/chief/eiinformation.html). The MOVES data used for 2002 and 2005 are not available through the 2002 and 2005 NEI website. This indicator aggregates NEI data by source type (anthropogenic or biogenic), source category, and EPA Region.

References

U.S. EPA (United States Environmental Protection Agency). 2013a. 2008 National Emissions Inventory, Version 3, technical support document. Draft report, in press.

U.S. EPA. 2013b. Data from the National Emissions Inventory, Version 3.0. Accessed 2013. http://www.epa.gov/ttn/chief/eiinformation.html.

Exhibit 1. Anthropogenic PM_{10} emissions in the U.S. by source category, 1990-2008



During some parts of the period of record, inventories were only developed every three years, hence the three-year intervals shown here. Data are available for inventory year 1993, but these data have not been updated to allow comparison with data from the other years shown.

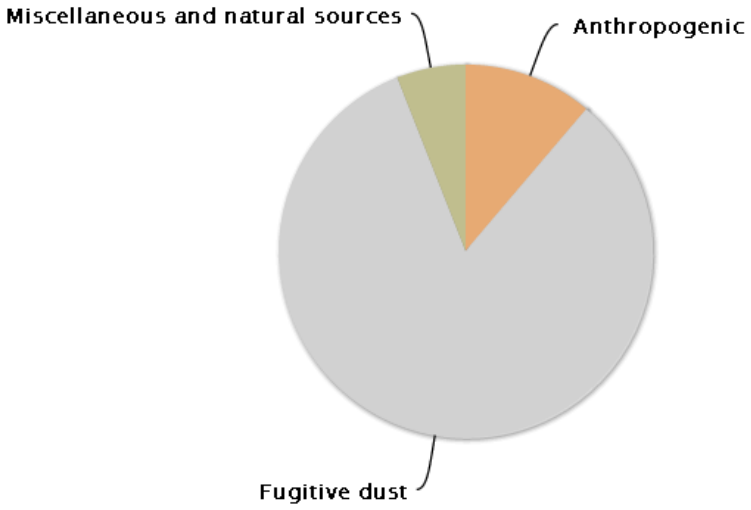
Starting in 1999, EPA began tracking condensable particulate emissions separately from filterable particulate emissions. In order to display data generated using a consistent methodology, emissions of condensable particulate are not included in this exhibit.

Changes shown from 1990–2008 include both emissions changes and methods changes. While trends shown are generally representative, actual changes from year to year could have been larger or smaller than those shown.

Information on the statistical significance of the trends in this exhibit is not currently available. For more information about uncertainty, variability, and statistical analysis, view the technical documentation for this indicator.

Data source: U.S. EPA, 2013b

Exhibit 2. Relative amounts of U.S. PM_{10} emissions from anthropogenic and other sources, 2008

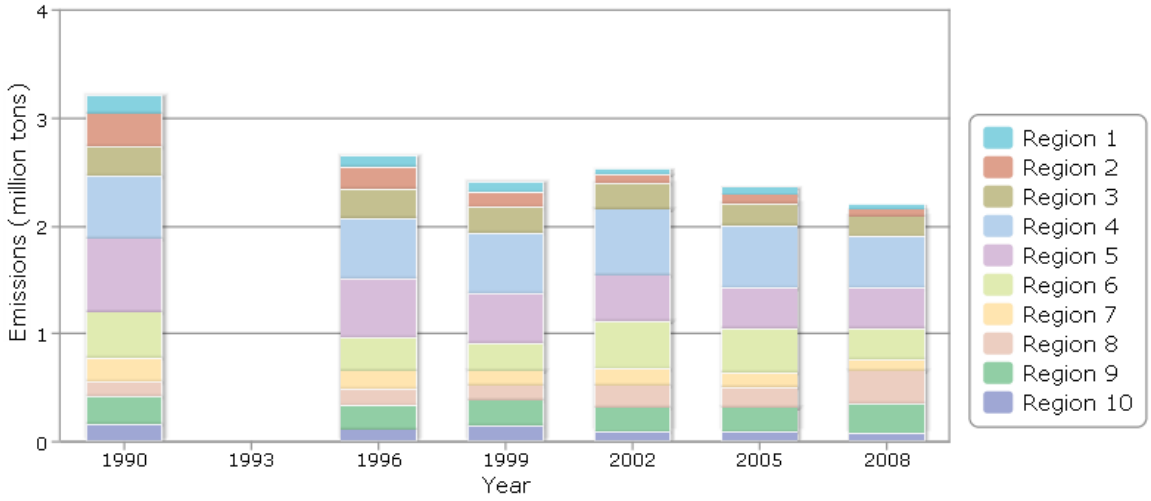


Starting in 1999, EPA began tracking condensable particulate emissions separately from filterable particulate emissions. This exhibit includes condensable and filterable particulate emissions.

Trend analysis has not been conducted because these data represent a single snapshot in time. For more information about uncertainty, variability, and statistical analysis, view the technical documentation for this indicator.

Data source: U.S. EPA, 2013b

Exhibit 3. Anthropogenic PM_{10} emissions in the U.S. by EPA Region, 1990-2008



During some parts of the period of record, inventories were only developed every three years, hence the three-year intervals shown here. Data are available for inventory year 1993, but these data have not been updated to allow comparison with data from the other years shown.

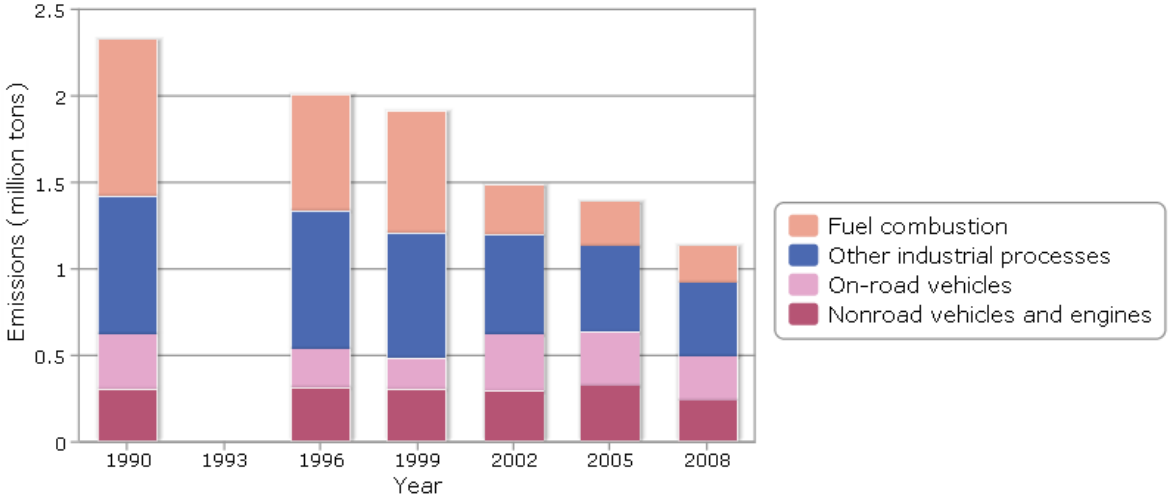
Starting in 1999, EPA began tracking condensable particulate emissions separately from filterable particulate emissions. In order to display data generated using a consistent methodology, emissions of condensable particulate are not included in this exhibit.

Changes shown from 1990–2008 include both emissions changes and methods changes. While trends shown are generally representative, actual changes from year to year could have been larger or smaller than those shown.

Information on the statistical significance of the trends in this exhibit is not currently available. For more information about uncertainty, variability, and statistical analysis, view the technical documentation for this indicator.

Data source: U.S. EPA, 2013b

Exhibit 4. Anthropogenic $PM_{2.5}$ emissions in the U.S. by source category, 1990-2008



During some parts of the period of record, inventories were only developed every three years, hence the three-year intervals shown here. Data are available for inventory year 1993, but these data have not been updated to allow comparison with data from the other years shown.

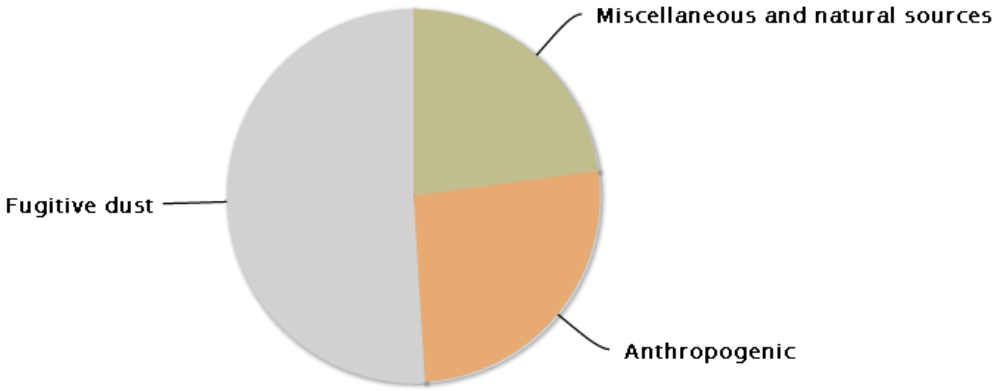
Starting in 1999, EPA began tracking condensable particulate emissions separately from filterable particulate emissions. In order to display data generated using a consistent methodology, emissions of condensable particulate are not included in this exhibit.

Changes shown from 1990–2008 include both emissions changes and methods changes. While trends shown are generally representative, actual changes from year to year could have been larger or smaller than those shown.

Information on the statistical significance of the trends in this exhibit is not currently available. For more information about uncertainty, variability, and statistical analysis, view the technical documentation for this indicator.

Data source: U.S. EPA, 2013b

Exhibit 5. Relative amounts of U.S. $PM_{2.5}$ emissions from anthropogenic and other sources, 2008

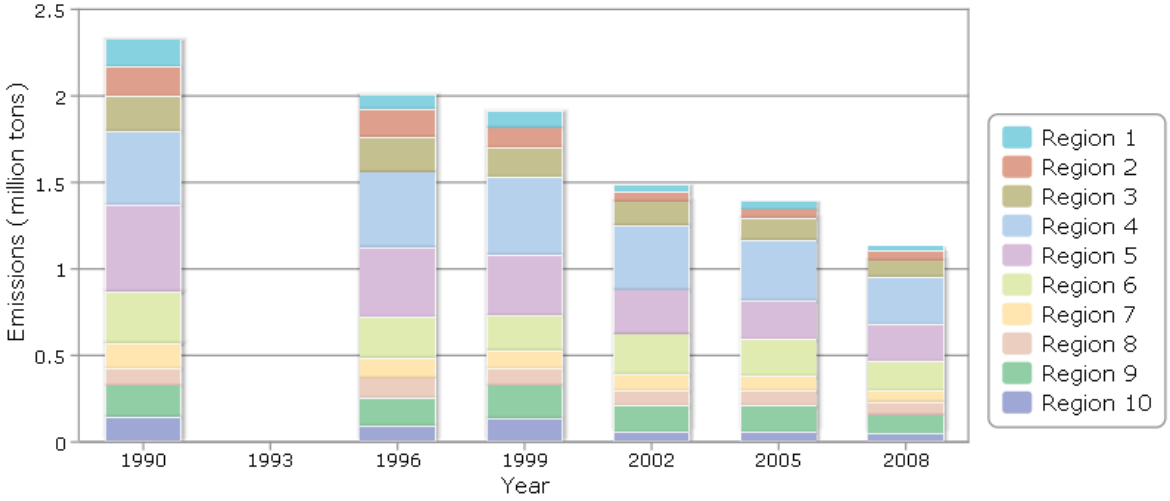


Starting in 1999, EPA began tracking condensable particulate emissions separately from filterable particulate emissions. This exhibit includes both condensable and filterable particulate emissions.

Trend analysis has not been conducted because these data represent a single snapshot in time. For more information about uncertainty, variability, and statistical analysis, view the technical documentation for this indicator.

Data source: U.S. EPA, 2013b

Exhibit 6. Anthropogenic $PM_{2.5}$ emissions in the U.S. by EPA Region, 1990-2008



During some parts of the period of record, inventories were only developed every three years, hence the three-year intervals shown here. Data are available for inventory year 1993, but these data have not been updated to allow comparison with data from the other years shown.

Starting in 1999, EPA began tracking condensable particulate emissions separately from filterable particulate emissions. In order to display data generated using a consistent methodology, emissions of condensable particulate are not included in this exhibit.

Changes shown from 1990–2008 include both emissions changes and methods changes. While trends shown are generally representative, actual changes from year to year could have been larger or smaller than those shown.

Information on the statistical significance of the trends in this exhibit is not currently available. For more information about uncertainty, variability, and statistical analysis, view the technical documentation for this indicator.

Data source: U.S. EPA, 2013b