

## Volatile Organic Compounds Emissions

Volatile organic compounds (VOCs) are a large group of organic chemicals that include any compound of carbon (excluding carbon monoxide, carbon dioxide, carbonic acid, metallic carbides or carbonates, and ammonium carbonate). VOCs are of interest in part because they participate in atmospheric photochemical reactions that contribute to ozone formation. Ozone (the [Ozone Concentrations indicator](#)) is formed from chemical reactions involving airborne VOCs, airborne nitrogen oxides, and sunlight. VOCs are also of interest because they play a role in formation of secondary organic aerosols, which are found in airborne particulate matter (the [Particulate Matter Concentrations indicator](#)). Finally, VOCs are of interest because many individual VOCs are known to be harmful to human health (the [Air Toxics Concentrations indicator](#); the [Air Toxics Emissions indicator](#)). Health effects vary by pollutant. VOCs are emitted from a variety of sources, including motor vehicles, chemical manufacturing facilities, refineries, factories, consumer and commercial products, and natural (biogenic) sources (mainly trees).

This indicator presents VOC emissions from 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. The indicator also includes estimates of biogenic VOC emissions in 2011. 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 2011 annual meteorological data. The indicator excludes VOC estimates of prescribed burning and other miscellaneous sources except in the calculation of the biogenic sources fraction, because those data were either not readily available in the 1990 inventory or are small contributors to the total inventory.

VOC emissions data are tracked by the National Emissions Inventory (NEI). The NEI is a composite of data from many different sources, including industry, EPA models, and numerous 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, 2015). For most fuel combustion sources and industrial sources, emissions are from the state, local, and tribal air quality management agencies and are estimated primarily 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, 2008, and 2011. 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

According to NEI data, national total estimated VOC emissions from anthropogenic sources, excluding wildfires and prescribed burns, decreased by 47 percent between 1990 and 2011 (from 23.0 million tons to 12.3 million tons) (Exhibit 1). The overwhelming majority of anthropogenic emissions reductions were observed among on-road mobile sources and other industrial processes. Combined, these two source categories accounted for 84 percent of the total nationwide estimated anthropogenic VOC emissions in 1990 (excluding wildfires and prescribed burns), but accounted for only 77 percent of the nationwide anthropogenic emissions in 2011.

This indicator focuses on trends in VOC emissions from anthropogenic sources. However, VOC emissions

from biogenic sources were estimated for 2011 to provide a sense of the relative contributions of natural versus anthropogenic emissions. Nationally, biogenic emissions were estimated to contribute approximately 74 percent to VOC emissions from all sources during 2011 (Exhibit 2). Biogenic emissions for this exhibit include emissions from wildfires and plants. Thus, VOC emissions from biogenic sources are larger than the VOC emissions from all anthropogenic sources combined.

In nine of the EPA Regions, estimated anthropogenic VOC emissions decreased between 1990 and 2011 (Exhibit 3). Changes in VOC emissions ranged from a 68 percent reduction (Region 9) to a 21 percent increase (Region 8).

## Limitations

- VOC emissions estimates through the NEI are provided only for the triennial NEI years starting with 1990 and continuing through 2011, with the exception of 1993.
- VOC emissions from “miscellaneous sources,” including wildfires and prescribed burning, are not included in the total anthropogenic emissions. Yearly fluctuations in wildfire emissions have the potential to mask trends in anthropogenic emissions and therefore have been excluded from this indicator's exhibits. Details on emissions from miscellaneous sources can be found on EPA’s emission inventory website ( <http://www3.epa.gov/ttn/chief/eiinformation.html>).
- VOC emissions data are largely based on estimates that employ emission factors generated from empirical and engineering studies, rather than on actual measurements of VOC emissions. These estimates are generated using well-established approaches, including extensively reviewed mobile source models, and quality assurance measures are implemented to ensure that the emissions data entered in NEI meet data quality standards (U.S. EPA, 2006). Nonetheless, 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 any revisions must be considered in the context of those changes.
- 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 model, and 2002, 2005, 2008, and 2011 emissions for this source category were estimated using different versions of the MOVES model which applied different methods. Therefore, the outputs may not be directly comparable across years; the change in model is reflected as part of the trend shown.
- Version 1 of the 2011 NEI was completed prior to the release of the most recent MOVES model (MOVES2014).

## Data Sources

Summary data in this indicator were provided by EPA’s Office of Air Quality Planning and Standards, based on biogenic and anthropogenic VOC emissions data in the NEI. The most recent data are taken from Version 1 of the 2011 NEI (U.S. EPA, 2014). These and earlier emissions data can be accessed from EPA’s emission inventory website ( <http://www3.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.

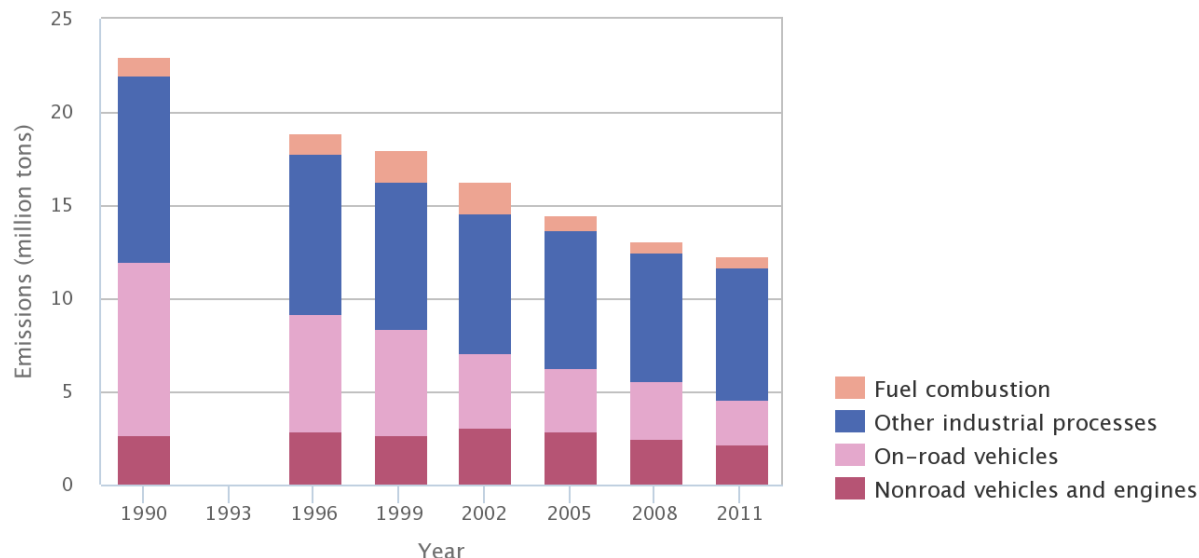
## References

U.S. EPA (United States Environmental Protection Agency). 2015. 2011 National Emissions Inventory, Version 2, technical support document. Draft report. [https://www.epa.gov/sites/production/files/2015-10/documents/nei2011v2\\_tsd\\_14aug2015.pdf](https://www.epa.gov/sites/production/files/2015-10/documents/nei2011v2_tsd_14aug2015.pdf) (PDF) (371 pp, 16.1MB).

U.S. EPA. 2014. Data from the 2011 National Emissions Inventory, Version 1. Accessed 2014. <https://www.epa.gov/air-emissions-inventories/2011-national-emissions-inventory-nei-data>.

U.S. EPA. 2006. NEI quality assurance and data augmentation for point sources. Research Triangle Park, NC. [https://www.epa.gov/sites/production/files/2015-11/documents/nei2002\\_qa\\_augmentation\\_0206.pdf](https://www.epa.gov/sites/production/files/2015-11/documents/nei2002_qa_augmentation_0206.pdf) (PDF) (127 pp, 278K).

**Exhibit 1. Anthropogenic VOC emissions in the U.S. by source category, 1990–2011**



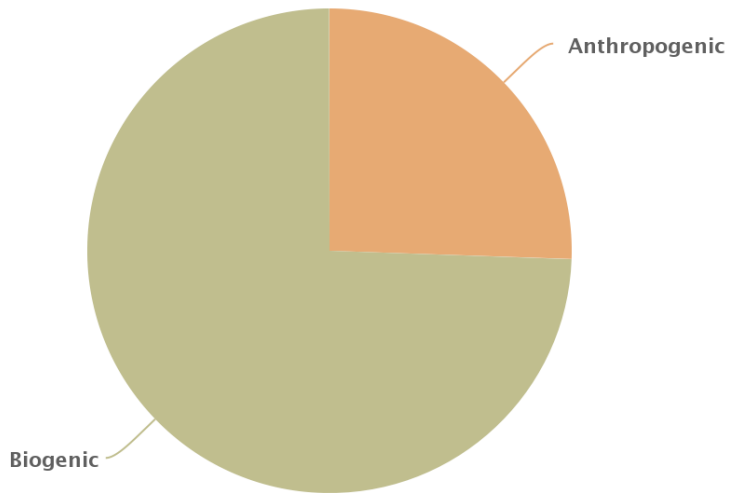
During some parts of the period of record, inventories were only developed every three years, hence the three-year intervals shown here. Data are available for inventory year 1993, but these data have not been updated to allow comparison with data from the other years shown.

Changes shown from 1990–2011 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, 2014b

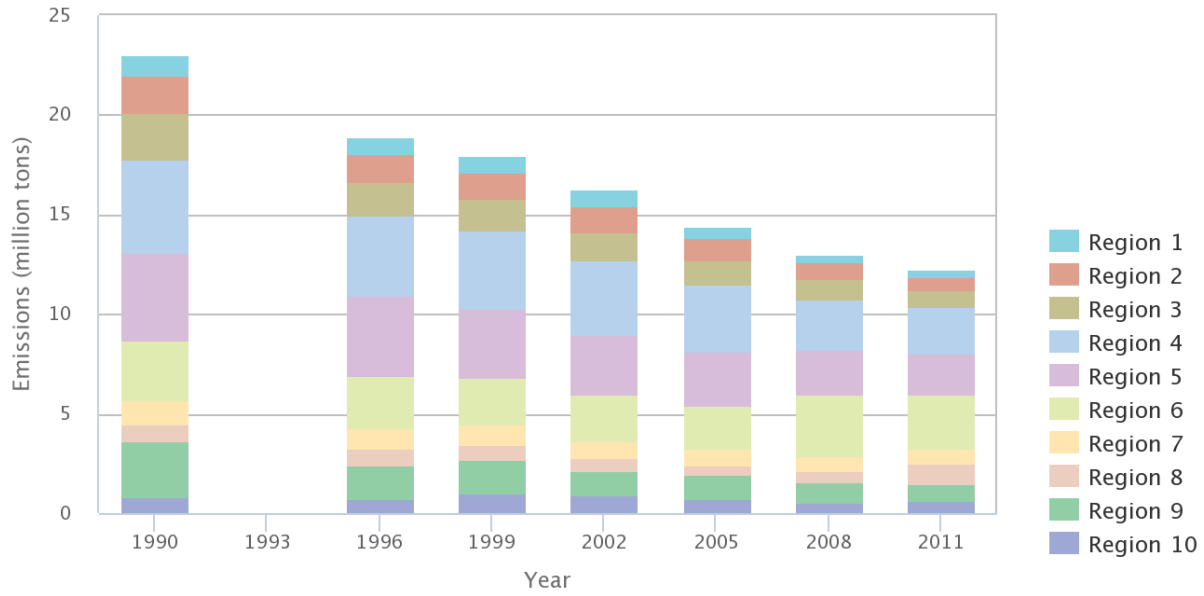
**Exhibit 2. Relative amounts of U.S. VOC emissions from anthropogenic and biogenic sources, 2011**



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, 2014b

### Exhibit 3. Anthropogenic VOC emissions in the U.S. by EPA Region, 1990–2011



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.

Changes shown from 1990–2011 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, 2014b