

TRANSPORTATION

Air Quality

Selected Facts and Figures



U.S. Department of Transportation
Federal Highway Administration

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PURPOSE AND TERMS

Purpose and Terms

What's It All About?

This brochure provides an overview of facts and figures regarding the linkages between transportation and air quality. The focus of this brochure is primarily on transportation-related emissions trends, policies, technologies, and standards that effect on-road mobile sources, including automobiles, light-duty trucks, and heavy-duty trucks.

Terms

AFV	Alternative-fuel vehicle.
AVCV	Automated vehicle/connected vehicle.
CAA	The Clean Air Act.
CAAA	The Clean Air Act Amendments of 1990.
CMAQ	Congestion Mitigation and Air Quality Improvement Program.
CNG	Compressed natural gas.
CO	Carbon monoxide, a product of incomplete combustion.
CO ₂	Carbon dioxide, not a criteria pollutant but a greenhouse gas.
Condensables	PM _{2.5} formed in the atmosphere from precursor gases, such as sulfur dioxide and oxides of nitrogen.
EPA	U.S. Environmental Protection Agency.
GHG	Greenhouse gas.
HC	Hydrocarbons, gaseous compounds made of carbon and hydrogen; the term is used interchangeably with VOCs.
I/M	Inspection and maintenance.
LNG	Liquefied natural gas.
LPG	Liquefied petroleum gas.
Maintenance area	Any geographic region previously designated as a nonattainment area and subsequently redesignated attainment subject to a maintenance plan.
MOVES	Motor Vehicle Emission Simulator.
MSAT	Mobile source air toxics.
NAAQS	National Ambient Air Quality Standards, federally established standards for pollutant concentrations that states, cities, and towns must meet by specified deadlines.

NEI	National Emissions Inventory.
Nonattainment area	A designated geographic area that has failed to meet the National Ambient Air Quality Standards.
Non-road engines	Aircraft, trains, boats, off-road recreational vehicles, farm and construction equipment, and yard tools.
NO _x	Oxides of nitrogen, a collective term for all compounds of nitrogen and oxygen, including nitrogen monoxide and nitrogen dioxide.
NO ₂	Nitrogen Dioxide.
O ₃	Ozone, an oxygen compound that can develop when oxides of nitrogen, volatile organic compounds, and sunlight interact in the lower atmosphere; the primary constituent of smog.
On-road vehicles	Cars, vans, buses, light-duty and heavy-duty trucks, and motorcycles.
PM	Particulate matter.
PM ₁₀	Particulate matter with a diameter less than 10 micrometers.
PM _{2.5}	Particulate matter with a diameter less than 2.5 micrometers.
Point and area sources	Stationary sources of emissions, including electric utilities, factories, petroleum refineries, dry cleaners, and others.
ppm	Parts per million.
Precursors	Pollutants that contribute to the formation of other pollutants; hydrocarbons and oxides of nitrogen are precursors of ozone and particulate matter.
SIP	State Implementation Plan.
SO ₂	Sulfur dioxide.
TCM	Transportation control measure.
ULSD	Ultra low-sulfur diesel.
VMT	Vehicle miles traveled.
VOCs	Volatile organic compounds, gaseous compounds made of carbon and hydrogen; the term is used interchangeably with HC.

Overview

What Is Transportation and Air Quality?

In response to the Clean Air Act (CAA), the U.S. Environmental Protection Agency (EPA) established National Ambient Air Quality Standards (NAAQS) for various pollutants—known as criteria pollutants—that adversely affect human health and welfare. This brochure focuses on the four major transportation-related criteria pollutants:

- Ozone (O₃) and its precursors: volatile organic compounds (VOCs) and oxides of nitrogen (NO_x)
- Particulate matter (PM)
- Carbon monoxide (CO)
- Nitrogen Dioxide (NO₂)

Other criteria pollutants include sulfur dioxide (SO₂) and lead. In the past, motor vehicles were a major source of lead emissions, however these were virtually eliminated when leaded gasoline was phased out.

Although not criteria air pollutants, toxic air pollutants, or air toxics, are pollutants that cause or may cause cancer or other serious health effects, such as reproductive effects or birth defects. Air toxics may also cause adverse environmental and ecological effects. The CAA identifies 188 air toxics. EPA has identified 21 pollutants as mobile source air toxics including diesel particulate matter, benzene, metals, and organic materials.

Fuel combustion by motor vehicles and other sources releases carbon dioxide (CO₂), which is a greenhouse gas that traps heat within the earth's atmosphere.

Significant progress has been made in reducing criteria pollutant emissions from motor vehicles and improving air quality since the 1970s, even as vehicle travel has increased. The air is noticeably cleaner than in 1970, and total criteria-pollutant emissions from motor vehicles are less than they were in 1970 despite a near tripling of vehicle miles of travel. With the reduction in criteria pollutants, many air toxics have also been reduced.

Still, challenges remain. In recent years, EPA has issued revised standards for O₃ and PM that reflect improved understanding of the health effects of these pollutants. Based on monitoring data, more than 150 million people in the United States reside in counties that do not meet the air-quality standards for at least one NAAQS pollutant. For more detailed data on many of the subjects covered, refer to the sources and websites listed in this publication.

Air Pollutants

How Do These Pollutants Affect Us?

Above certain concentrations, ozone, PM, and CO can cause or exacerbate health problems and/or increase mortality rates, making their control an important goal under the CAA.

What Is Ozone (O₃)?

Ground-level ozone is the major component of smog. While ozone in the upper atmosphere (the ozone layer) occurs naturally and protects life on earth from harmful ultraviolet radiation, ozone at ground level is a noxious pollutant. Ground-level ozone is not directly emitted, but is formed by the reaction of NO_x and VOCs in the presence of sunlight.

Ozone is a severe irritant, responsible for the choking, coughing, and stinging eyes associated with smog. Ozone damages lung tissue, aggravates respiratory disease, and makes people more susceptible to respiratory infections. Children are especially vulnerable to ozone's harmful effects, as are adults with existing disease. Even healthy individuals may experience impaired lung function from breathing ozone-polluted air. In addition to affecting human health, ozone harms vegetation, resulting in reduced agricultural and commercial forest yields, increased tree and plant susceptibility to disease and other environmental stresses, and potential long-term effects on forests and ecosystems. Peak concentrations typically occur in summer.

What Is Particulate Matter (PM)?

PM is the term used for a mixture of solid particles and liquid droplets found in the air. These particles come in a wide range of sizes and can remain suspended in the air for extended periods. PM can be emitted directly by a source or formed in the atmosphere by the transformation of gaseous emissions, such as SO₂, NO_x, and VOCs.

Fine particles, fewer than 2.5 microns in diameter (PM_{2.5}), result from fuel combustion by motor vehicles and other sources, as well as transformation of gaseous emissions. Coarser particles up to 10 microns in diameter (PM₁₀) generally consist of windblown dust and are released from agriculture, and crushing and grinding operations.

Particulate matter irritates the membranes of the respiratory system, causing increased respiratory problems and disease, decreased lung function, alterations of the body's defense systems, and premature mortality. Sensitive groups include the elderly, individuals with cardiopulmonary disease such as asthma, and children. In addition to health problems, airborne particles cause soiling and damage to materials and reduce visibility in many parts of the United States.

What Is Carbon Monoxide (CO)?

CO is an odorless, colorless gas that interferes with the delivery of oxygen to the body's organs and tissues. Effects of CO include dizziness, headaches, fatigue, visual impairment, reduced work capacity, reduced manual dexterity, and poor learning ability. The health effects of CO vary depending on the length and intensity of exposure and the health of the individual, and are most serious for those who suffer from cardiovascular disease.

The incomplete burning of carbon in fuels such as gasoline produces CO. High concentrations of CO occur along side roads with heavy traffic, particularly at major intersections, and in enclosed areas, such as garages and poorly ventilated tunnels. Peak concentrations typically occur during the colder months of the year when vehicular emissions of CO are greater and nighttime inversion conditions are more frequent.

What Is Nitrogen Dioxide (NO₂)?

NO₂ is one of a group of highly reactive gasses known as "oxides of nitrogen," or "nitrogen oxides (NO_x)." NO₂ forms quickly from emissions from cars, trucks and buses, power plants, and off-road equipment. In addition to contributing to the formation of ground-level ozone and fine particle pollution, NO₂ is linked with a number of adverse effects on the respiratory system.

Air Quality Standards

What Are the National Ambient Air Quality Standards (NAAQS)?

The NAAQS are set by EPA to protect public health and welfare. Primary standards are designed to protect against adverse health effects, while secondary standards protect against welfare effects, such as damage to crops, vegetation, buildings, and visibility.

Primary Air Quality Standards for Transportation-Related Pollutants (2015)

Pollutant	Type of Average	Concentration
CO	8-hour	9 ppm 35 ppm
NO ₂	1-hour Annual	100 ppb 53 ppb
O ₃	8-hour	0.070 ppm
PM _{2.5}	Annual 24-hour	12 µg/m ³ 35 µg/m ³
PM ₁₀	24-hour	150 µg/m ³
ppm = parts per million. ppb = parts per billion. µg/m ³ = micrograms per cubicmeter		

Source: U.S. EPA, <http://www3.epa.gov/ttn/naaqs/criteria.html>

An area is in violation of a standard if it exceeds the concentration level for its evaluation time frames. For example, for an area to attain the 8-hour ozone standard, the 3-year average of the fourth-highest daily maximum 8-hour average ozone concentrations measured at each monitor within the year must not exceed 0.070 ppm.

What Are Nonattainment Areas?

Areas that do not meet the NAAQS are designated as nonattainment areas. The CAA requires States to develop plans, known as State Implementation Plans (SIPs), to attain the standards for each area designated nonattainment for a NAAQS. If the areas do not meet these and other requirements, they face CAA-required sanctions and other penalties, including loss of highway funds. Metropolitan planning organizations and the U.S. Department of Transportation (U.S. DOT) must ensure that transportation plans, programs, and projects conform to these SIPs.

What Are Maintenance Areas?

A maintenance area is any geographic region of the United States that EPA previously designated as a nonattainment area for one or more pollutants pursuant to the Clean Air Act Amendments of 1990 (CAAA), and subsequently redesignated as an attainment area subject to the requirement to develop a maintenance plan under Section 175A of the Clean Air Act, as amended. The maintenance plan normally contains an emissions or modeling demonstration that shows how the area will stay in compliance through the 20-year maintenance period.

NONATTAINMENT AND MAINTENANCE AREAS

Nonattainment and Maintenance Areas

Am I Living in a Nonattainment Area?

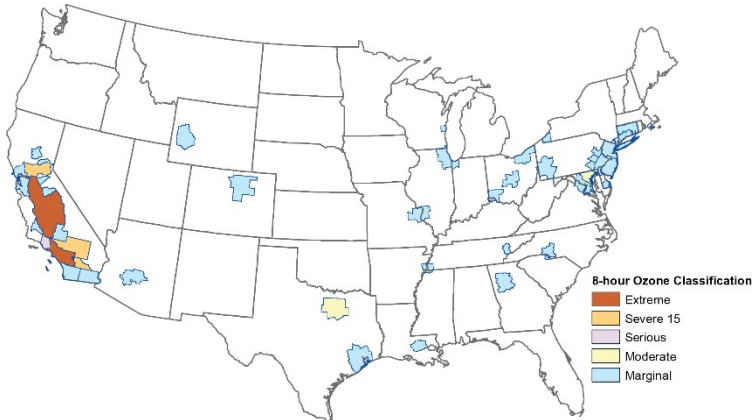
The maps on the following pages show the nonattainment areas for the various pollutants. Additional information can be found in the Green Book on EPA's website at <http://www3.epa.gov/airquality/greenbk/>.

Where Are the Ozone Nonattainment Areas?

On October 26, 2015, EPA adopted a more stringent 8-hour ozone health-based standard of 0.070 ppm. EPA will designate in 2017 both new nonattainment classification ranges and those areas that exceed the 2015 standard. To avoid backsliding, or losing progress toward attaining the 8-hour ozone standard, specific control measures for the previous 1-hour standard may be required to stay in place until an area attains the 8-hour standard.

The map below shows the ozone nonattainment areas designated under the older 2008 8-hour standard of 0.075 ppm. The classification of 8-hour ozone nonattainment areas can range from marginal with an 8-hour design value of up to 0.086 ppm O₃, to extreme with an 8-hour design value equal to or above 0.175 ppm O₃.

Ozone Nonattainment Areas (January 2015)

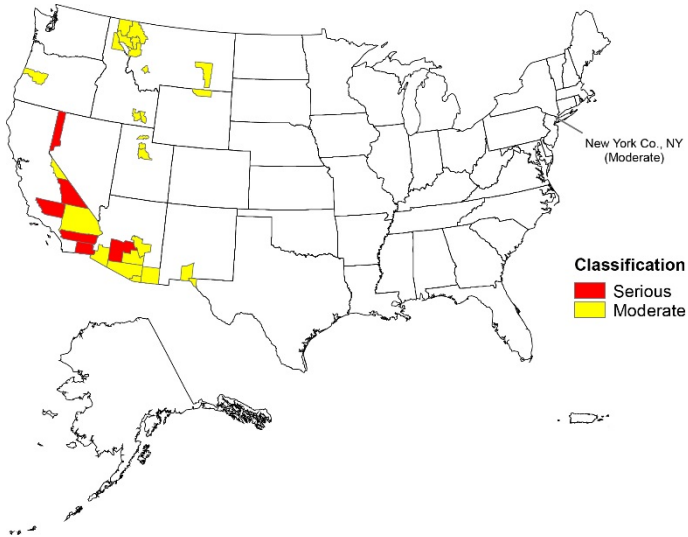


Source: U.S. Environmental Protection Agency, Green Book, January 2015,
<http://www3.epa.gov/airquality/greenbk/>
http://www3.epa.gov/oaqps001/greenbk/map8hr_2008.html

Where Are the PM_{10} Nonattainment Areas?

This map shows that a majority of the PM_{10} nonattainment areas are located in the western half of the United States, where a drier climate contributes to the formation of greater PM_{10} pollution.

PM_{10} Nonattainment Areas (January 2015)

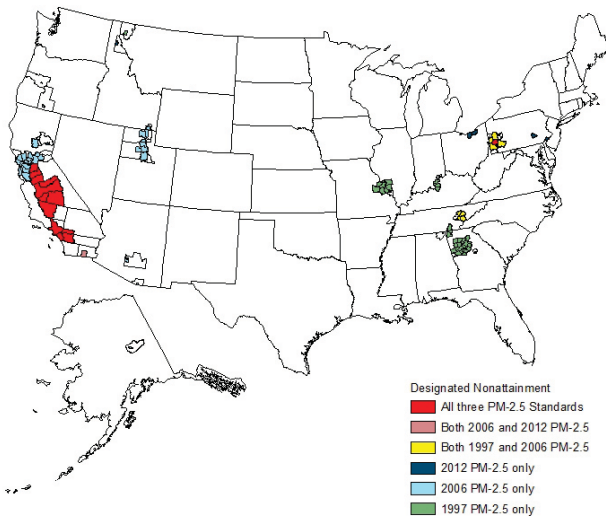


Source: U.S. Environmental Protection Agency, Green Book, January 2015, <http://www3.epa.gov/airquality/greenbk/mappm10.html>

Where Are the PM_{2.5} Nonattainment Areas?

This map shows that a majority of the PM_{2.5} nonattainment areas are located in the western half of the United States and in industrial areas in the east.

Counties Designated Nonattainment for PM_{2.5}
(October 2015)



Nonattainment areas are indicated by color. When only a portion of a county is shown in color, it indicates that only that part of the county is within a nonattainment area boundary

Source: U.S. Environmental Protection Agency, Green Book, October 2015,
<https://www3.epa.gov/airquality/greenbook/mappm25both.html>

Where Are the CO Nonattainment Areas?

As of September 2010, all CO areas have been redesignated to maintenance areas. Great progress has been made in reducing CO emissions since 1970.

Where Are the NO₂ Nonattainment Areas?

Los Angeles-South Coast Air basin was redesignated to a NO₂ maintenance area in 1998. All other areas of the country presently meet the current NO₂ NAAQS, with annual concentrations well below the level of the standard (53 ppb). Annual average ambient NO₂ concentrations have decreased by more than 40 percent since 1980.

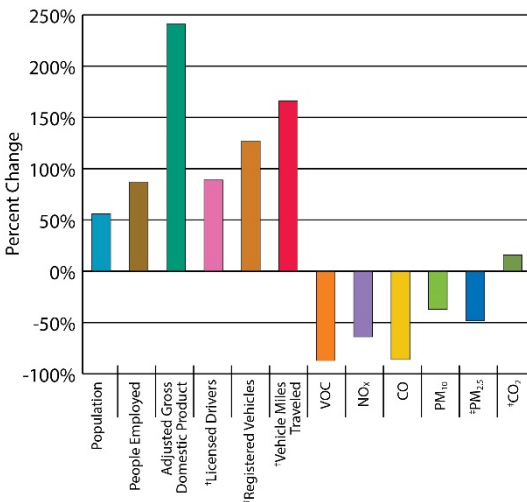
PROGRESS IN REDUCING MOTOR VEHICLE EMISSIONS

Progress in Reducing Motor Vehicle Emissions

Have We Made Progress in Reducing Motor Vehicle Emissions?

Air pollution emissions from motor vehicles have dropped considerably since 1970—VOC emissions are down 87 percent, NO_x emissions are down 64 percent, PM₁₀ emissions are down 37 percent, and CO emissions are down 86 percent. Since 1990, PM_{2.5} emissions are down 48 percent; however transportation carbon dioxide (CO₂) emissions increased 16 percent. The reductions are due primarily to more stringent light-duty engine and fuel standards. These occurred at the same time as a 56 percent increase in population, 241 percent growth in gross domestic product, and 166 percent growth in VMT.

Percent Change in Motor Vehicle Emissions, Demographics, and Travel (1970–2013)



Notes: Figures for licensed 'drivers, 'registered vehicles and 'VMT are from 2011. Data for 'PM_{2.5} and 'CO₂ are from 1990.

Sources: Bureau of Transportation Statistics, National Transportation Statistics, Table 1-35, March 2014, http://www.rita.dot.gov/bts/sites/rita.dot.gov/bts/files/publications/national_transportation_statistics/html/table_01_35.html

U.S. Census Bureau, Population Division, Table 1, Annual Estimates of the Resident Population for the United States, Regions, States, and Puerto Rico: April 1, 2010 to July 1, 2014 (NST-EST2014-01), <http://www.census.gov/popest/data/national/totals/2014/NST-EST2014-alldata.html>

U.S. Department of Commerce, Bureau of Economic Analysis, National Economic Accounts, May 2015, <http://www.bea.gov/National/index.htm>

U.S. Department of Labor, Bureau of Labor Statistics, The Employment Situation—February 2015, http://www.bls.gov/news.release/archives/empsit_03062015.pdf

Federal Highway Administration, Office of Highway Policy Information, Highway Statistics 2011, Chart DV-1C, December 2012, <http://www.fhwa.dot.gov/policyinformation/statistics/2011/dv1c.cfm>

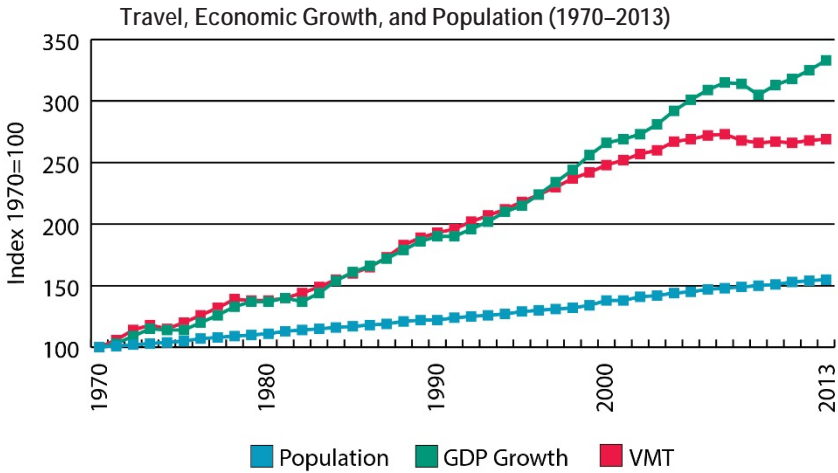
Federal Highway Administration Highway Statistics 2013, Public Road Mileage - VMT - Lane Miles 1920–2013, Chart VMT-421C, <http://www.fhwa.dot.gov/policyinformation/statistics/2013/vmt421c.cfm>

U.S. Environmental Protection Agency, Clearinghouse for Inventories and Emissions Factors (CHIEF), Current Emission Trends Summaries, <http://www3.epa.gov/ttn/chief/trends/index.html>

U.S. Environmental Protection Agency, Inventory of U.S. Greenhouse Gas Emissions and Sinks, <http://www3.epa.gov/climatechange/ghgemissions/inventoryexplorer/#allsectors/allgas/econsect/all>

Trends in Travel

What Are the Nation's Trends in Travel?

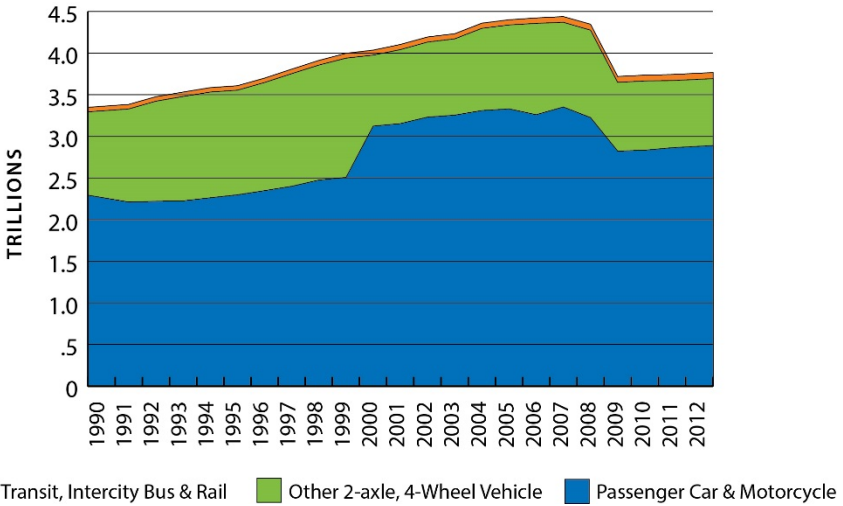


Sources: Bureau of Transportation Statistics, National Transportation Statistics, Table 1-35, March 2014, http://www.rita.dot.gov/bts/sites/rita.dot.gov/bts/files/publications/national_transportation_statistics/html/table_01_35.html
U.S. Census Bureau, Population Division, Table 1, Annual Estimates of the Resident Population for the United States, Regions, States, and Puerto Rico: April 1, 2010 to July 1, 2014 (NST-EST2014-01), <http://www.census.gov/popest/data/national/totals/2014/NST-EST2014-alldata.html>
U.S. Department of Commerce, Bureau of Economic Analysis, National Economic Accounts, May 2015, <http://www.bea.gov/National/index.htm>
U.S. Department of Labor, Bureau of Labor Statistics, The Employment Situation—February 2015, http://www.bls.gov/news.release/archives/empsit_03062015.pdf

Since 1970, growth in VMT has far outpaced population growth. VMT growth tracked closely with economic growth until the mid-2000s, but has since leveled off even as gross domestic product has increased.

How Many Miles Do We Travel in Vehicles?

Surface Passenger Miles Traveled (1990–2012)



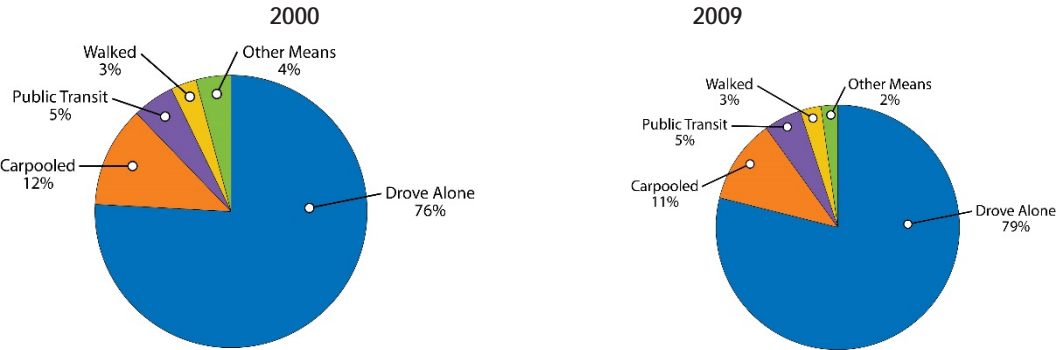
Source: Bureau of Transportation Statistics, National Transportation Statistics, Table 1-40, January 2015, http://www.rita.dot.gov/bts/sites/rita.dot.gov.bts/files/publications/national_transportation_statistics/html/table_01_40.html

Between 1990 and 2012, the number of surface passenger miles traveled increased by 418 billion. Americans use cars more than any other form of ground transportation—98 percent of all passenger miles were traveled in personal vehicles (automobiles, motorcycles, and light-duty trucks) in 2012. From 1990 to 2012, transit and intercity bus and rail use increased by 18.8 billion passenger miles, or 26 percent.

FHWA anticipates growth in total VMT by all vehicle types to average 1.04 percent annually from 2013–2033. Growth in total VMT is expected to slow to only about 0.2 percent annually during the ensuing decade (2033–2043), reducing the average growth rate over the entire 30-year forecast period (2013–2043) to 0.76 percent annually. This represents a significant slowdown from the growth in total VMT experienced over the past 30 years, which averaged 2.08 percent annually.

Source: FHWA Forecasts of Vehicle Miles Traveled (VMT): May 2015, Office of Highway Policy Information Federal Highway Administration, June 5, 2015, http://www.fhwa.dot.gov/policyinformation/tables/vmt/vmt_forecast_sum.pdf

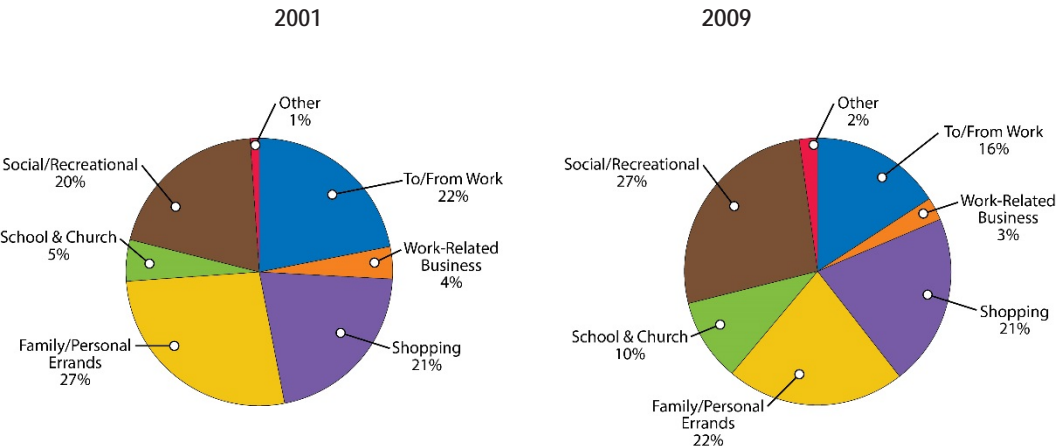
How Do We Get to Work?



Source: U.S. Census Bureau, American Community Survey, 2009, Supplemental Table A, [https://www.census.gov/newsroom/releases/pdf/supplemental_table_a\[1\].pdf](https://www.census.gov/newsroom/releases/pdf/supplemental_table_a[1].pdf)

Americans commute to work in single-occupant vehicles more than by any other method. In 2000, 76 percent of the workforce drove to work alone. That percentage increased to 79 percent in 2009. The share of people commuting by transit and carpooling declined slightly in the same period.

Why Do We Take a Vehicle Trip?

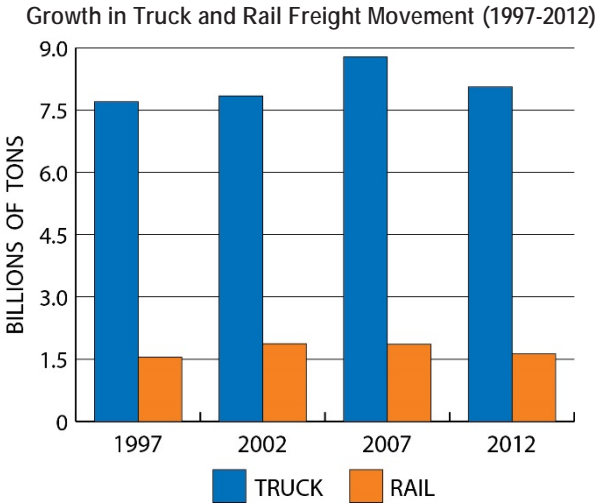


Source: FHWA 2009 National Household Travel Survey, Summary of Travel Trends, Table 5, January 2011, <http://nhts.ornl.gov/2009/pub/stt.pdf>

Commuting has declined significantly as a share of all vehicle trips. In 2001, 22 percent of all vehicle trips were made traveling to or from work. By 2009, only 16 percent of all trips were made for traveling to or from work.

What is the Growth in Freight Movement?

The ability of our nation's transportation system to provide for and maintain the efficient movement of freight is important to the continuing economic health of the United States. Between 1997 and 2012, the amount of freight moved by truck and rail grew by 5 percent each.

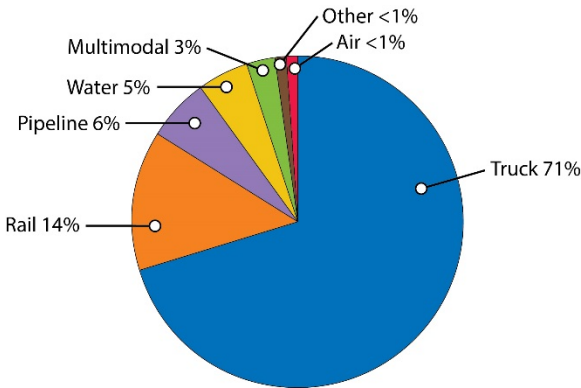


Source: U.S. Department of Transportation, Bureau of Transportation Statistics, Transportation Commodity Flow Survey, June 2015, http://www.rita.dot.gov/bts/sites/rita.dot.gov/bts/files/publications/commodity_flow_survey/2012/united_states/table1b

How Does This Freight Move Around?

In 2012, trucks and rail carried the largest percentage of domestic commercial ton-miles, followed by pipeline, water, and multimodal.

Percentage of U.S. Commercial Freight Movement (2012)



Source: U.S. Department of Transportation, Bureau of Transportation Statistics, Transportation Commodity Flow Survey, Table 1a, June 2015, http://www.rita.dot.gov/bts/sites/rita.dot.gov/bts/files/publications/commodity_flow_survey/2012/united_states/table1a

What About Freight and Air Quality?

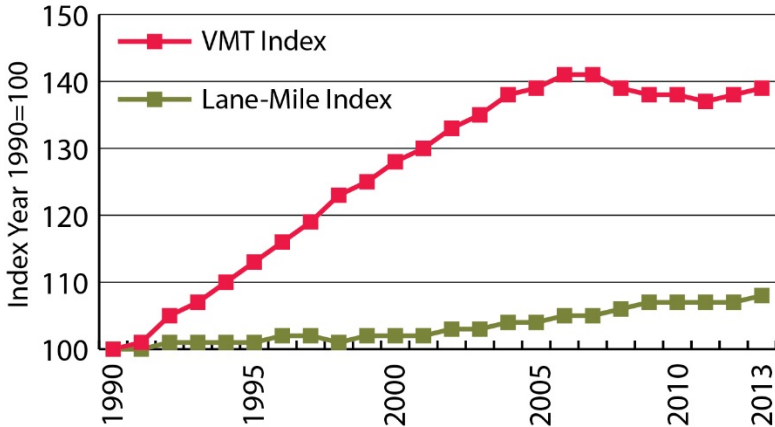
Diesel exhaust from freight vehicles is a primary source of PM_{2.5}, air toxic contaminants, and NO_x emissions. Freight emissions comprise close to one-third of U.S. transportation greenhouse gas emissions. This growth in freight movement and accompanying increase in emissions has led to a growing need to find new ways to address air quality concerns and greenhouse gas emissions associated with freight movement.

Marine cargo vessels and port complexes are a large source of diesel freight emissions. In addition to cargo ships, ports use cranes, hostlers, and other equipment powered by diesel fuel. Cargo vessels typically burn bunker fuel. They are a major contributor to air quality issues in coastal regions. Cargo ships usually switch to their auxiliary engines to provide power for ship operations while they are in port. Although some auxiliary engines use cleaner fuel than the main engines, they still contribute to localized air pollution around port complexes since the ships may be idling for days at a time. To combat this problem, many ports are constructing shore power (also known as cold ironing) systems that provide cleaner electrical power to cargo vessels while they are in port.

Source: Federal Highway Administration, Freight and Air Quality Handbook, May 2010, <http://www.ops.fhwa.dot.gov/publications/fhwahop10024/index.htm>

How Do Vehicle Miles Traveled and Lane Mileage Compare?

Growth of VMT and Lane Mileage (1990–2013)



Source: U.S. Department of Transportation, Federal Highway Administration, Highway Statistics 2013 (Washington, DC: Annual Issues), Table VM-422C, <http://www.fhwa.dot.gov/policyinformation/statistics.cfm>

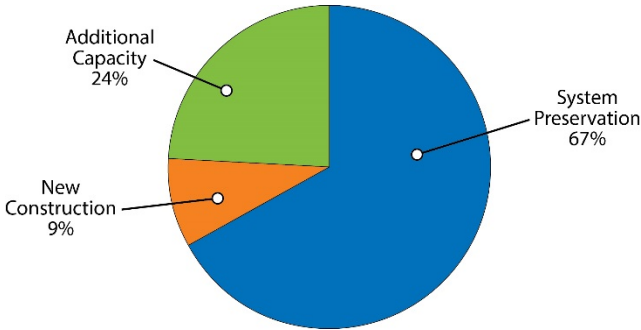
Despite significant growth in VMT, lane miles have increased only slightly since 1990. Over more than 20 years, VMT has increased 37 percent, while lane miles have increased only 7 percent. This is mitigated somewhat by targeted traffic flow improvements in some communities that enhance capacity without additional lane mileage.

Roads and Spending

How Much Are We Spending on Roads?

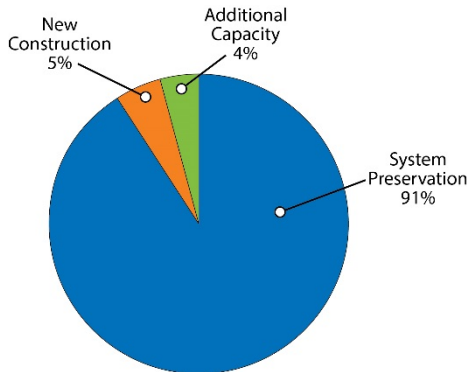
In 2013, \$19 billion in federal funds were obligated, and 65,500 miles of federal-aid roadway projects were implemented.

Obligation of Federal Funds for Roads (2013)



Sixty-seven percent of the obligated funds went towards system preservation, new construction comprised nine percent, and additional capacity projects received 24 percent.

Miles of Federal-Aid Roadway Projects (2013)



Ninety-one percent of the project miles involved system preservation, five percent of the miles involved new construction, and four percent involved additional capacity.

Source: Federal Highway Administration, Highway Statistics 2011, Table FA-10, Obligation of Federal-Aid Highway Funds for Highway Improvements, <http://www.fhwa.dot.gov/policyinformation/statistics/2011/fa10.cfm>

Note: This chart excludes funds and miles related to safety and environmentally related projects, and new bridges and bridge replacement/rehabilitation.

Traffic Congestion

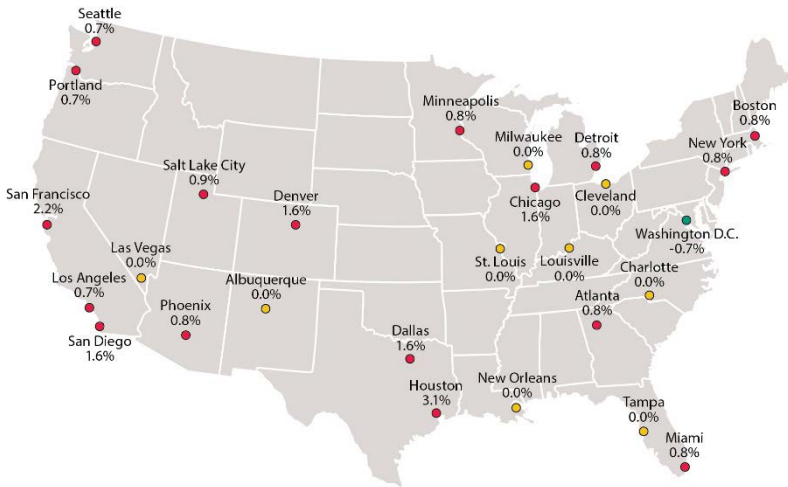
Is Traffic Congestion in Our Cities Getting Better or Worse?

Congestion occurs when the free flow of traffic on a roadway is impeded due to excess vehicle demand, construction, maintenance, traffic incidents, weather, or other road conditions and events.

Before the 2008 economic recession, congestion was increasing at between 2 and 4 percent every year—which meant that extra travel time for the average commuter increased slightly less than 1 hour every year. The economic recession set back that trend a few years, but the trend in the last few years indicates congestion is rising again.

This map shows the percent change from 2011 to 2014 in the amount of time per trip it took to travel in the peak period for selected areas.

Changes in Traffic Congestion (2011–2014)



Source: Texas A&M Transportation Institute, 2015 Urban Mobility Report, August 2015, Table 1, <http://tti.tamu.edu/documents/mobility-scorecard-2015.pdf>

What Are the Major Sources of Congestion?

FHWA studies show that congestion is the result of seven root causes, often interacting with one another.


- **Physical Bottlenecks (“Capacity”)**—capacity is the maximum amount of traffic capable of being handled by a given highway section. When demand is greater than capacity, physical limitations can cause congestion.
- **Traffic Incidents**—events that disrupt the normal flow of traffic such as vehicular crashes, breakdowns, and debris in travel lanes.
- **Work Zones**—construction activities on the roadway that result in physical changes to the highway environment. These changes may include a reduction in the number or width of travel lanes, lane “shifts,” lane diversions, reduction or elimination of shoulders, and even temporary roadway closures.
- **Weather**—environmental conditions can lead to changes in driver behavior that affect traffic flow.
- **Traffic Control Devices**—Intermittent disruption of traffic flow by control devices such as railroad grade crossings and poorly timed signals.
- **Special Events**—demand fluctuations whereby traffic flow in the vicinity of an event (sports, concerts) will be radically different from “typical” patterns. Special events occasionally cause “surges” in traffic demand that overwhelm the system.
- **Fluctuations in Normal Traffic**—Day-to-day variability in demand leads to some days with higher traffic volumes than others.

Source: Federal Highway Administration, *Traffic Congestion and Reliability: Linking Solutions to Problems Report*, July 2004, http://ops.fhwa.dot.gov/congestion_report_04/index.htm#toc

Emissions Sources

What are Sources of Emissions?

Emissions that affect air quality come from many sources. EPA groups sources into 8 major categories. The table below provides more detail about which sources are included in each sector.

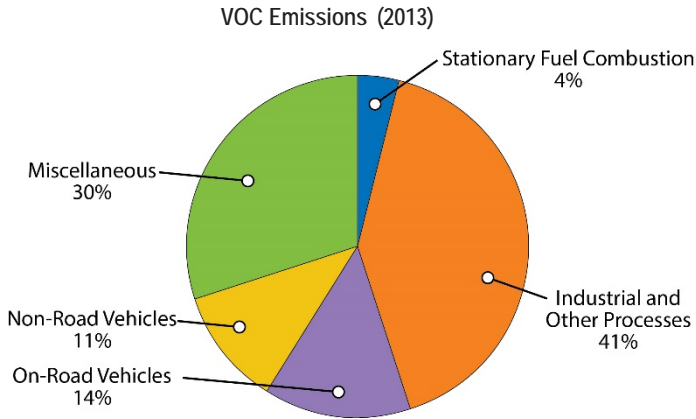
Type of source	Emissions
 Agriculture	Crops & Livestock Dust; Fertilizer Application; Livestock Waste
 Dust	Construction Dust, Paved Road Dust, Unpaved Road Dust
 Fire	Agricultural Field Burning, Prescribed Fires, Wildfires
 Fuel Combustion	Commercial/Institutional (Biomass, Coal, Natural Gas, Oil, Other); Electric Generation (Biomass, Coal, Natural Gas, Oil, Other); Industrial Boilers and Internal Combustion Engines (Biomass, Coal, Natural Gas, Oil, Other); Residential (Natural Gas, Oil, Wood, Other)
 Industrial Processes	Cement Manufacturing, Chemical Manufacturing, Ferrous Metals, Mining, National Electric Code (NEC), Non-ferrous Metals, Oil & Gas Production, Petroleum Refineries, Pulp & Paper, Storage and Transfer
 Miscellaneous	Bulk Gasoline Terminals; Commercial Cooking Gas Stations; Miscellaneous Non-Industrial NEC; Waste Disposal
 Mobile	Aircraft; Commercial Marine Vessels; Locomotives; Non-Road Equipment – Diesel; Non-Road Equipment – Gasoline; Non-Road Equipment – Other; On-Road Diesel Heavy Duty Vehicles; On-Road Diesel Light Duty Vehicles; On-Road Gasoline Heavy Duty Vehicles; On-Road Gasoline Light Duty Vehicles
 Solvent	Consumer & Commercial Solvent Use; Degreasing Dry Cleaning; Graphic Arts; Industrial Surface Coating & Solvent Use; Non-Industrial Surface Coating

Source: U.S. Environmental Protection Agency, <http://www3.epa.gov/air/emissions/basic.htm>

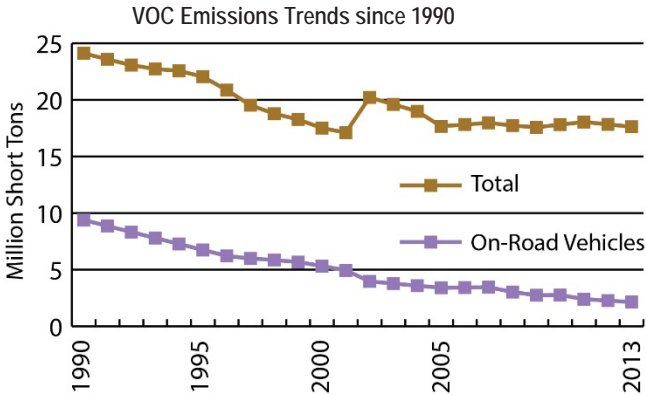
EMISSIONS TRENDS

Emissions Trends

How Have VOC Emissions Changed since 1990?

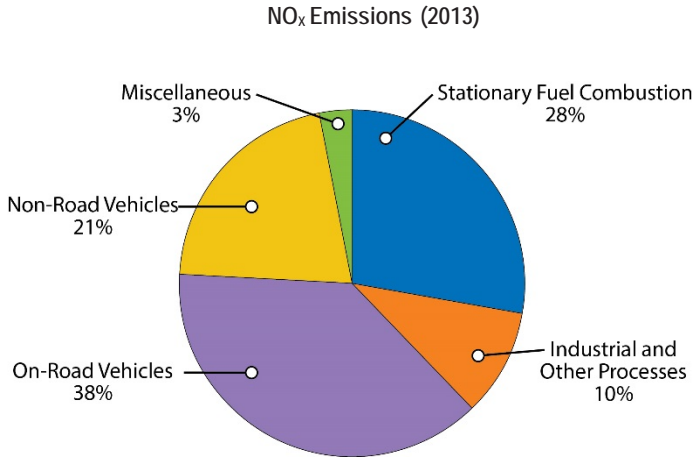


VOCs are precursors of ground-level ozone and PM. In 2013, on-road vehicles produced 14 percent of all VOC emissions, down from 39 percent in 1990. On-road vehicle VOC emissions have decreased 77 percent in the last two decades.

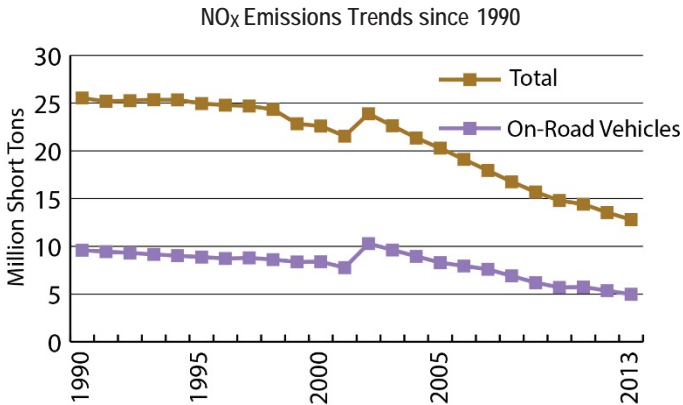


Source: U.S. Environmental Protection Agency, Clearinghouse for Inventories and Emissions Factors (CHIEF), Current Emission Trends Summaries, <http://www3.epa.gov/ttn/chief/trends/index.html>

How Have NO_x Emissions Changed since 1990?



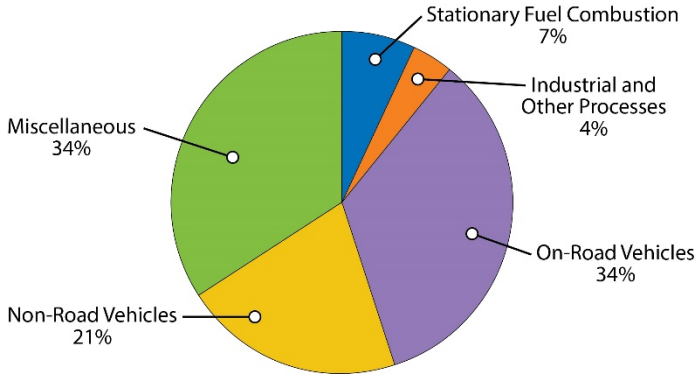
In combination with VOCs, NO_x contributes to the formation of ozone. It is also a precursor to PM. In 2013, on-road vehicles produced 38 percent of all NO_x emissions, the same as in 1990. However, total on-road vehicle emissions of NO_x have decreased 48 percent since 1990.



Source: U.S. Environmental Protection Agency, Clearinghouse for Inventories and Emissions Factors (CHIEF), Current Emission Trends Summaries, <http://www3.epa.gov/ttn/chief/trends/index.html>

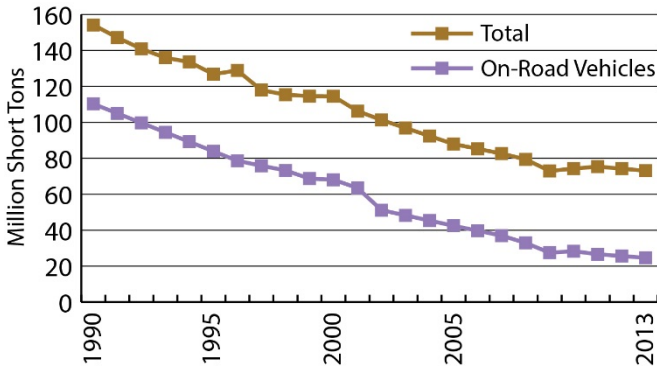
How Have CO Emissions Changed since 1990?

CO Emissions (2013)



On-road vehicles are one of the largest sources of CO emissions. However, by 2013, on-road vehicles produced 34 percent of all CO emissions, down from 72 percent in 1990.

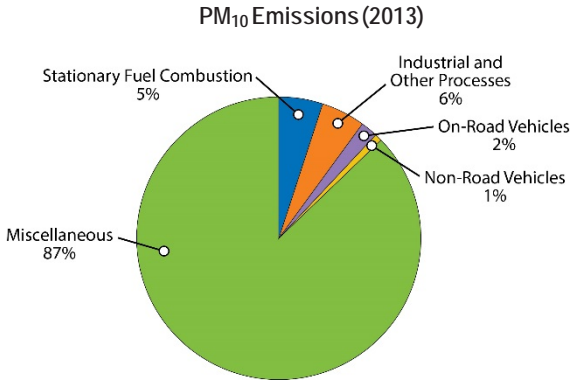
CO Emissions Trends since 1990



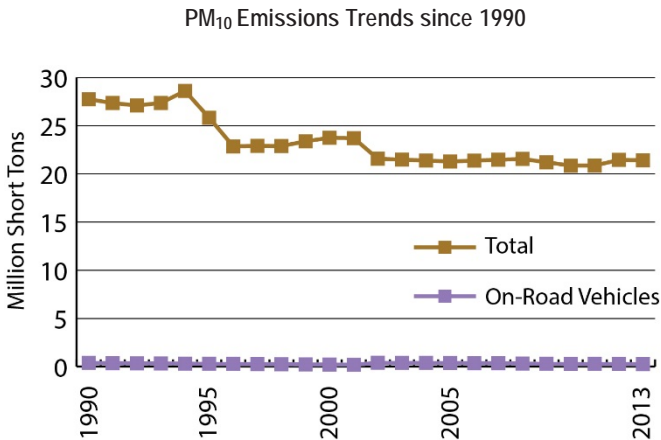
Source: U.S. Environmental Protection Agency, Clearinghouse for Inventories and Emissions Factors (CHIEF), Current Emission Trends Summaries, <http://www3.epa.gov/ttn/chief/trends/index.html>

How Have PM₁₀ Emissions Changed since 1990?

PM₁₀ consists of dust, direct smoke, and liquid droplets. The majority of PM₁₀ emissions come from sources such as prescribed fires and wildfires, dust from paved and unpaved roads, road construction, and agriculture operations (designated Miscellaneous in the pie chart below). Sources such as fuel combustion, industrial sources, and transportation, together make up only 13 percent of total PM₁₀ emissions.



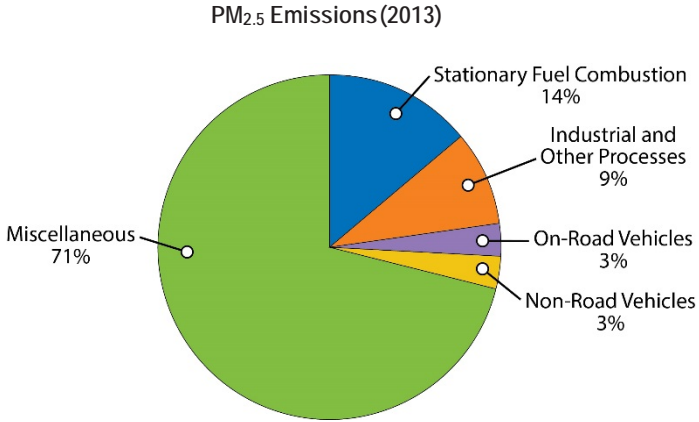
PM₁₀ from all sources declined over 23 percent between 1990 and 2013, and on-road vehicle PM₁₀ emissions decreased over 31 percent.



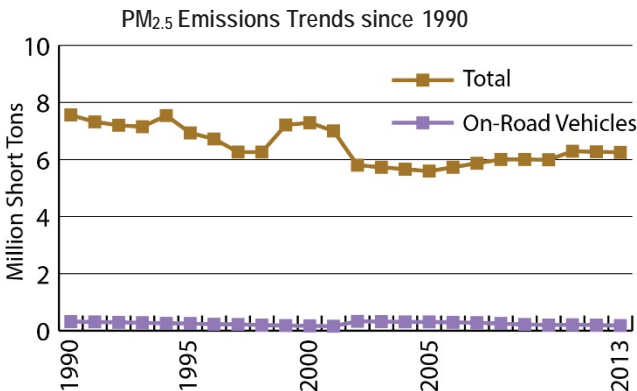
Source: U.S. Environmental Protection Agency, Clearinghouse for Inventories and Emissions Factors (CHIEF), Current Emission Trends Summaries, <http://www3.epa.gov/ttn/chief/trends/index.html>

How Have PM_{2.5} Emissions Changed since 1990?

PM_{2.5} results from motor vehicle fuel combustion and other sources. Most PM_{2.5} emissions come from sources such as prescribed fires and wildfires, dust from paved and unpaved roads, road construction, and agriculture operations (designated Miscellaneous in the pie chart below). Sources such as fuel combustion, industrial sources, and transportation, together make up 29 percent of total PM_{2.5} emissions.



Since 1990, PM_{2.5} from all sources decreased by almost 17 percent. Although on-road exhaust and emissions from brake and tire wear accounted for only 3 percent of the direct PM_{2.5} emissions in 2013, on-road vehicle PM_{2.5} emissions declined more than 43 percent since 1990.

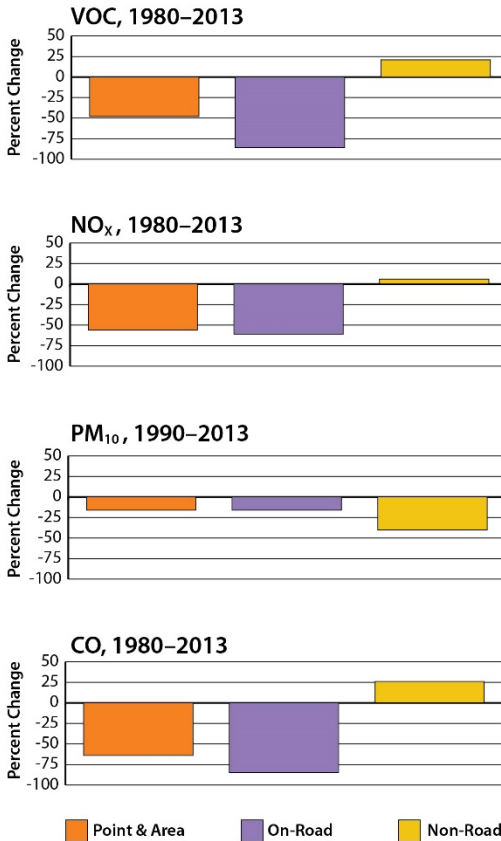


Source: U.S. Environmental Protection Agency, Clearinghouse for Inventories and Emissions Factors (CHIEF), Current Emission Trends Summaries, <http://www3.epa.gov/ttn/chieftrends/index.html>

Note: 1990-1998 emissions do not include condensables. Condensables are the majority of PM_{2.5} that is formed in the atmosphere from precursor gases such as SO₂ and NO_x.

How Have Emissions Changed in the Last 30 Years?

America made great progress cleaning the air. For nearly 30 years, national emissions trends for point and area sources and on-road sources have declined. However, non-road source emissions increased with the exception of PM₁₀.



Source: U.S. EPA Office of Air and Radiation, <http://www3.epa.gov/air/trends/index.html>
Note: Data for PM₁₀ begins in 1990.

What has Caused the Improvement?

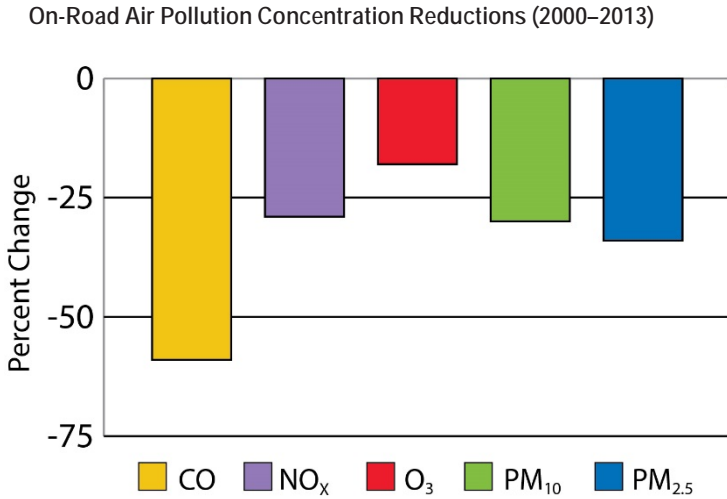
A great deal of the credit for the improvements in on-road sources goes to cleaner cars and trucks, and fuels.

AIR QUALITY TRENDS

Air Quality Trends

How Much Progress Is Being Made?

As on-road air pollutant emissions decline over time, air quality improves. Reductions in air pollutant concentrations are impressive, with concentrations of CO decreasing by 60 percent since 2000. All criteria pollutants have shown significant decreases over the last decade, showing a steady trend of improvement.



Sources: U.S. Environmental Protection Agency, Clearinghouse for Inventories and Emissions Factors (CHIEF), Current Emission Trends Summaries, <http://www3.epa.gov/ttn/chief/trends/index.html>

Mobile Source Air Toxics

What Are Mobile Source Air Toxics?

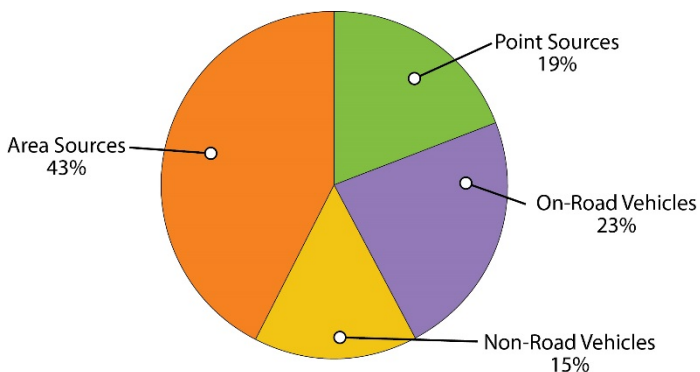
Mobile source air toxics are compounds emitted from highway vehicles and non-road equipment which are known or suspected to cause cancer or other serious health and environmental effects. Mobile sources are responsible for direct emissions of air toxics and contribute to precursor emissions which react to form secondary pollutants. Examples of mobile source air toxics include benzene, 1,3-butadiene, formaldehyde, acrolein, polycyclic organic matter, naphthalene, and diesel particulate matter.

What Efforts Are Being Made?

In February 2007, EPA finalized the Control of Hazardous Air Pollutants from Mobile Sources rule to reduce hazardous air pollutants from mobile sources. The rule limits the benzene content of gasoline and reduces toxic emissions from passenger vehicles and gas cans. EPA estimates that by 2030 this rule will reduce total emissions of mobile source air toxics by 330,000 tons and VOC emissions (precursors to ozone and PM_{2.5}) by over 1 million tons. EPA adopted mobile source emissions control programs that, in addition to controlling pollutants such as hydrocarbons, particulate matter, and nitrogen oxides, also result in large air toxic reductions.

The chart below shows the source contributions for air toxics. On-road vehicles account for about one-quarter of all air toxic emissions.

National Contribution of Each Emissions Source Type (2011)



Source: U.S. Environmental Protection Agency, <http://www.epa.gov/orcdizux/toxics.htm>

What Are the Important Mobile Source Air Toxics in Transportation?

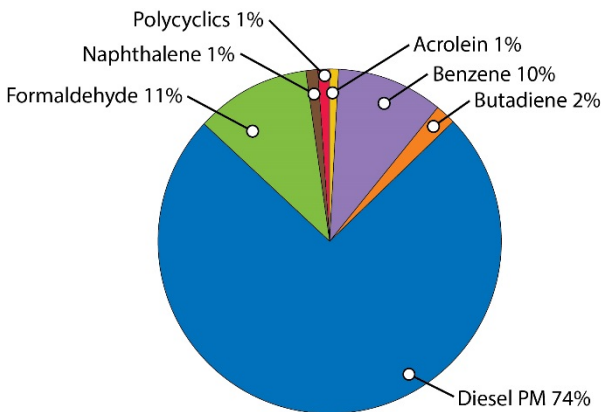
The EPA 1999 National Air Toxics Assessment (NATA) identified seven compounds with significant contributions from mobile sources that are among the national and regional-scale cancer risk drivers:

- Acrolein
- Benzene
- 1,3-butadiene
- Formaldehyde
- Diesel particulate matter and diesel exhaust organic gases
- Naphthalene
- Polycyclic organic matter

Some of these chemicals (such as benzene) are present in gasoline and diesel fuel and are emitted through evaporation or when fuel passes through an engine without being burned. Others (such as formaldehyde and diesel particulate matter) are not present in the fuel itself; rather, they are byproducts of incomplete combustion. These compounds have a variety of potential human health effects. Benzene, for instance, is a known carcinogen.

The chart below shows the estimated proportion of emissions from the seven notable MSATs from on-road vehicle activity in 2015.

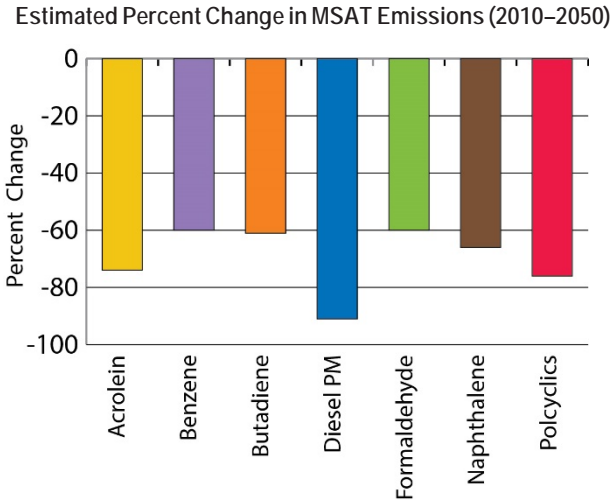
Distribution of MSATs Emissions from On-Road Vehicles (2015)



Source: Federal Highway Administration,
http://www.fhwa.dot.gov/environment/air_quality/air_toxics/policy_and_guidance/aqintguidmem.cfm

How Much of the Transportation MSATs Can Be Reduced?

The following chart shows the estimated on-road reductions in seven MSATs through 2050 despite an expected 102 percent increase in national VMT. The decreases are derived from improved vehicle technology and emissions modeling tools.



Trends for specific locations may be different, depending on locally derived information representing vehicle-miles travelled, vehicle speeds, vehicle mix, fuels, emissions control programs, meteorology, and other factors.

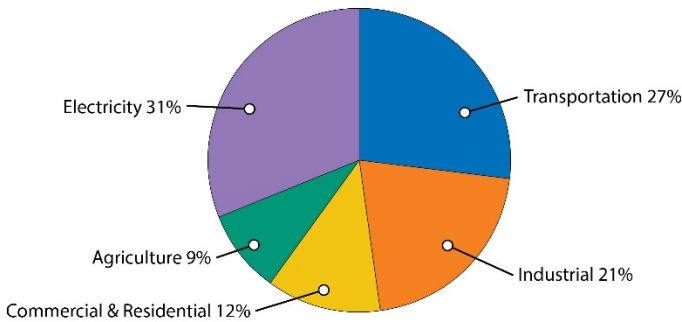
Sources: Federal Highway Administration memorandum, Interim Guidance Update on Mobile Source Air Toxic Analysis in NEPA, December 2012, http://www.fhwa.dot.gov/environment/air_quality/air_toxics/policy_and_guidance/qaqintguidmem.cfm#fig1

Greenhouse Gas Emissions

What about Greenhouse Gas Emissions?

Greenhouse gases (GHGs) trap heat within the earth's atmosphere. Although most GHGs occur naturally and help keep the earth hospitable to life, they are also generated by human activities. CO₂ emissions account for more than 80 percent of the U.S. GHG emissions. These emissions are contributing to changes in the planet's climate that could lead to harmful effects, such as sea-level rise and changes in global hydrological patterns. Although the United States makes up 4.4 percent of the world's population, it emits about 16 percent of carbon emissions from fossil fuel combustion.

Sources of Greenhouse Gases (2013)



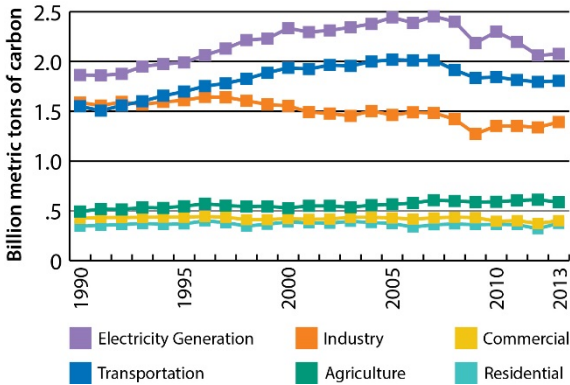
Source: U.S. Environmental Protection Agency, U.S. Greenhouse Gas Inventory Report: 1990-2013, <http://www3.epa.gov/climatechange/ghgemissions/usinventoryreport.html>

Greenhouse gas emissions from transportation primarily come from burning fossil fuel for our cars, trucks, ships, trains, and planes. Overall, transportation contributes 27 percent of national GHG emissions.

Source: Boden, T.A., Marland, G., and Andres, R.J. (2015). National CO₂ Emissions from Fossil-Fuel Burning, Cement Manufacture, and Gas Flaring: 1751-2011, Carbon Dioxide Information Analysis Center, Oak Ridge National Laboratory, U.S. Department of Energy, doi 10.3334/CDIAC/00001_V2015. http://cdiac.ornl.gov/trends/emis/tre_coun.html

In contrast to most criteria pollutants, emissions of GHGs have been rising from most sectors. From 1990 to 2013, carbon emissions from transportation grew by 16 percent.

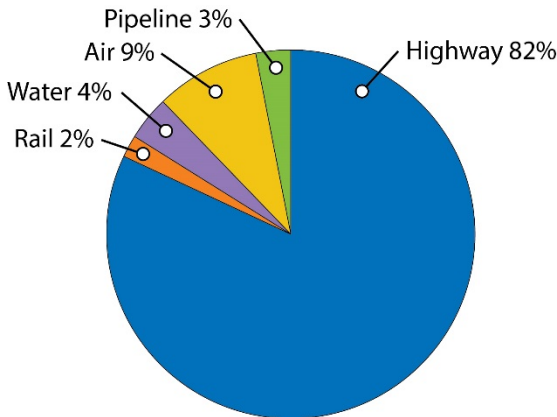
Change in Carbon Emissions (1990–2013)



Source: U.S. Environmental Protection Agency, U.S. Greenhouse Gas Inventory Report: 1990-2013, <http://www3.epa.gov/climatechange/Downloads/ghgemissions/US-GHG-Inventory-2015-Chapter-2-Trends.pdf>

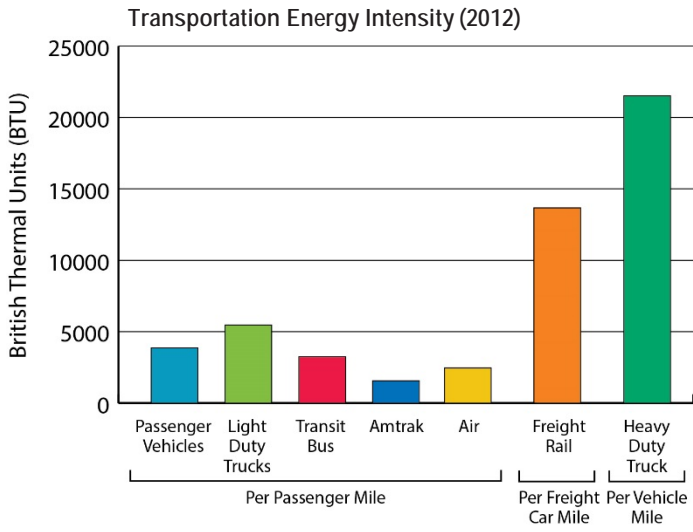
Highway vehicles are the largest users of transportation energy, accounting for 82 percent of the total.

Transportation Energy Use by Mode (2012)



Source: U.S. Energy Information Administration, Annual Energy Outlook 2015, Table A7—Transportation Sector Key Indicators and Delivered Energy Consumption, April 2015, <http://www.eia.gov/beta/aeo/#/?id=7-AEO2015>

The amount of energy used and its intensity is an indicator for the amount of GHGs produced. Per passenger mile, transit and passenger rail commuter transportation modes are less energy intense than light-duty passenger vehicles. However, light-duty trucks are more energy intense. For freight transport, heavy-duty trucks are considerably more energy intense than rail on a ton-mile basis.



Source: Bureau of Transportation Statistics, National Transportation Statistics, Table 4-20, 4-25: Energy Intensity of Passenger Modes, April 2015,
http://www.rita.dot.gov/bts/sites/rita.dot.gov.bts/files/publications/national_transportation_statistics/html/table_04_20.html
http://www.rita.dot.gov/bts/sites/rita.dot.gov.bts/files/publications/national_transportation_statistics/html/table_04_25.html
Transportation Energy Data Book: Edition 33, ORNL-6990, Oak Ridge National Laboratory, July 2014,
http://cta.ornl.gov/data/tebd34/Spreadsheets/Table2_17.xls

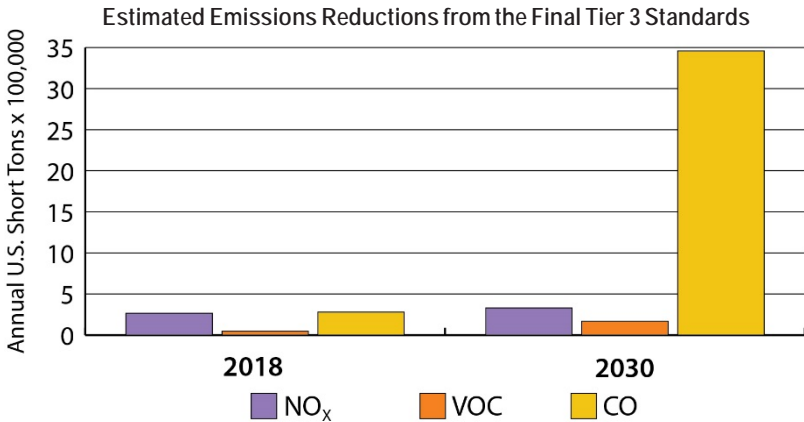
Emissions Standards

What Are the Federal Emissions Standards?

The CAA set federal emissions-control standards for all new cars and light trucks sold in the United States. The CAAA established stringent Tier 1 emissions standards, which became effective in 1994. More stringent Tier 2 emissions standards were adopted in 2004. In April 2014, EPA finalized new Tier 3 emissions-control standards.

What Do the New Tier 3 Emissions Standards Do?

Starting in 2017, Tier 3 standards will set new vehicle emissions standards and lower the sulfur content of gasoline, considering the vehicle and its fuel as an integrated system. The new standards reduce both tailpipe and evaporative emissions from passenger cars, light-duty trucks, medium-duty passenger vehicles, and some heavy-duty vehicles.



Source: U.S. Environmental Protection Agency, Office of Transportation and Air Quality, EPA Sets Tier 3 Motor Vehicle Emission and Fuel Standards, EPA- 420-F-14-009, March 2014, <http://www3.epa.gov/otaq/documents/tier3/420f14009.pdf>

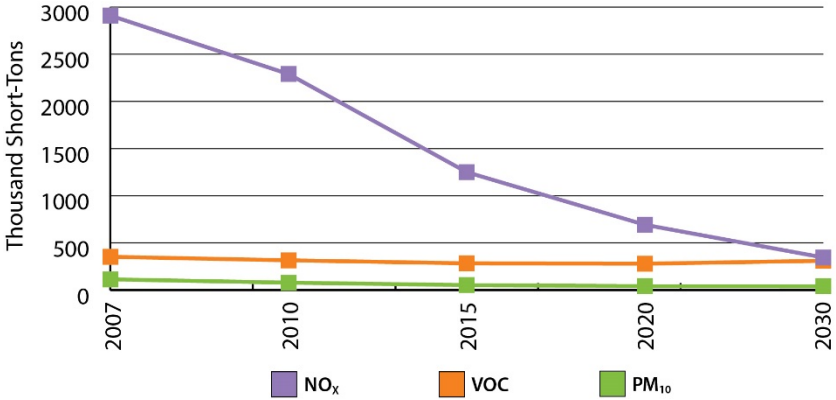
What Are the Benefits?

The Tier 3 gasoline sulfur standard will make emissions-control systems more effective for both existing and new vehicles, and will enable more stringent vehicle emissions standards. Removing sulfur allows the vehicle's catalyst to work more efficiently. Lower-sulfur gasoline also facilitates the development of some lower-cost technologies to improve fuel economy and reduce GHG emissions, which reduces gasoline consumption.

What Are the Heavy-Duty Diesel Emissions Standards?

In December 2000, EPA issued the final rule for a two-part strategy to reduce diesel emissions from heavy-duty trucks and buses. This included new diesel-engine standards in model year 2004 for all diesel vehicles over 8,500 pounds. These standards are based on the use of high-efficiency advanced emissions controls.

Estimated Vehicle Emissions Under Heavy-Duty Engine/Fuel Rule (2007–2030)



Source: U.S. Environmental Protection Agency, Heavy-Duty Engine and Vehicle Standards and Highway Diesel Fuel Sulfur Control Requirements, December 2000, <http://www3.epa.gov/otaq/regs/hd-hwy/2000frm/420r00026.pdf>

What Are the Fuel Efficiency and GHG Emissions Standards for Heavy-Duty Trucks?

The nation's fleet of medium- and heavy-duty trucks are required to meet fuel efficiency and GHG emissions standards for three categories of medium- and heavy-duty trucks:

- Certain combination tractors, commonly known as big rigs or semi-trucks, are required to achieve an approximately 20 percent reduction in fuel consumption and GHG emissions by model year 2018, saving up to 4 gallons of fuel for every 100 miles traveled.
- For heavy-duty pickup trucks and vans, separate standards are required for gasoline-powered and diesel trucks. These vehicles are required to achieve up to about a 15 percent reduction in fuel consumption and GHG emissions by model year 2018. Under the finalized standards, a typical gasoline or diesel powered heavy-duty pickup truck or van could save 1 gallon of fuel for every 100 miles traveled.
- Vocational vehicles, including delivery trucks, buses, and garbage trucks, are required to reduce fuel consumption and GHG emissions by approximately 10 percent by model year 2018. These trucks could save an average of 1 gallon of fuel for every 100 miles traveled.

In 2015, EPA and the National Highway Traffic Safety Administration (NHTSA) issued a notice of proposed rulemaking (NPRM) to establish a comprehensive Phase 2 Heavy Duty National Program that will reduce GHG emissions and fuel consumption for new on-road heavy duty vehicles. This program would phase in over the long-term, beginning in the 2018 model year and culminating in standards for model year 2027.

Source: U.S. Environmental Protection Agency, Office of Transportation and Air Quality, *Paving the Way toward Cleaner, More Efficient Trucks*, EPA-420-F-11-032, August 2011, <http://www3.epa.gov/otaq/climate/documents/420f11032.pdf>

U.S. Environmental Protection Agency, *Cutting Carbon Pollution, Improving Fuel Efficiency, Saving Money, and Supporting Innovation for Trucks*, EPA-420-F-15-900, June 2015, <http://www3.epa.gov/otaq/climate/documents/420f15900.pdf>

What Are the Non-Road Vehicle Emissions Standards?

Non-road diesel engines include excavators and other construction equipment, farm tractors and other agricultural equipment, heavy forklifts, airport ground service equipment, and utility equipment such as generators, pumps, and compressors. Non-road diesel engines are subject to a set of tiered emissions standards. Tier 1 through 4 standards are currently in effect, having been implemented in steps since 1998. The regulations have been phased in for newly manufactured engines in different years depending on the power output of the engine. Each tier represents a progression to more stringent regulations.

Tier 4 standards were implemented from 2008 to 2015 and call for stricter limits on NO_x and PM (about a 90 percent reduction in emissions). EPA also has mandated the use of lower sulfur diesel fuel to enable more advanced pollution control on these engines. Since 2010, ultra-low sulfur diesel fuel is required, containing only 15 ppm of sulfur. Engine manufacturers must produce new engines with advanced emissions control technologies similar to those expected for highway trucks and buses. Exhaust emissions from these engines will decrease by more than 90 percent.

In 2008, EPA adopted more stringent emissions standards and mandated the application of idle-emission controls on newly manufactured and remanufactured locomotives. The idle reduction technology automatically shuts locomotives down if they are left idling unnecessarily. While such devices cannot eliminate all idling, they can reduce most unnecessary idling.

What Effects Do the Standards Have on Pollutants?

These standards removed 99 percent of the sulfur in diesel fuel by 2010, resulting in dramatic reductions in soot from all diesel engines.

The Non-road Diesel Rule complements the Clean Diesel Truck and Bus Rule. The new standards were estimated to result in reductions of pollution equivalent to having some 2 million fewer trucks on the road.

Sources: U.S. Environmental Protection Agency, <http://www3.epa.gov/otaq/nonroad-diesel.htm>
U.S. Environmental Protection Agency, Clean Air Nonroad Diesel Rule-Regulatory Announcement, Publication No. EPA420-F-04-032, May 2004, <http://www3.epa.gov/otaq/documents/nonroad-diesel/420f04032.pdf>
U.S. Environmental Protection Agency, Clean Diesel Programs-Facts and Figures, Publication No. EPA420-F-04-040, May 2004, <http://www3.epa.gov/diesel/documents/420f04040.pdf>
U.S. Environmental Protection Agency, Control of Emissions from Idling Locomotives, December 2013, <http://www3.epa.gov/otaq/regs/nonroad/locomotiv/420f13050.pdf>

Vehicle Emissions

What Are the Sources of Vehicle Emissions?

The power to move a motor vehicle comes from burning fuel in an engine. Emissions from vehicles are the by-products of this combustion process. In addition, VOCs escape through fuel evaporation. As vehicle exhaust systems have improved, evaporative emissions have become a larger component of total-vehicle VOC emissions.

What Emissions Come from Vehicle Exhaust?

The combustion process results in emissions of VOC, NO_x, PM, and CO, which are released from the tailpipe while a vehicle is operating. Exhaust emissions occur during two modes:

- Start emissions—Starting a vehicle and the first few minutes of driving generate higher emissions because the emissions-control equipment has not yet reached its optimal operating temperature.
- Running exhaust emissions—Pollutants are emitted from the vehicle's tailpipe during driving and idling after the vehicle is warmed up.

What VOC Emissions Come from Fuel Evaporation?

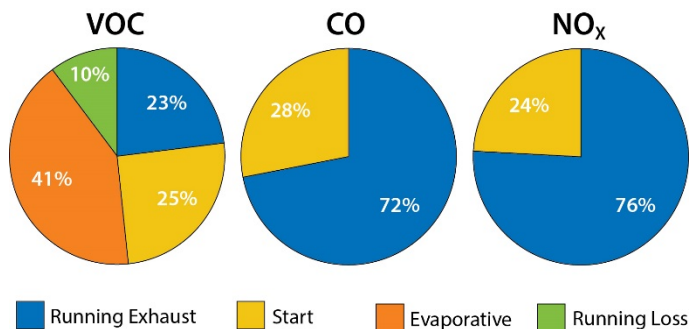
VOCs also escape into the air through fuel evaporation. Despite evaporative emissions controls, evaporative losses can still account, on hot days, for a majority of the total VOC pollution from current-model cars. Evaporative emissions occur in several ways:

- Running losses—The hot engine and exhaust system can vaporize gasoline while the vehicle is running.
- Hot soak (cooling down)—The engine remains hot for a period of time after the vehicle is turned off, and gasoline evaporates when the car is parked while cooling down.
- Diurnal (while parked and the engine is cool)—Even when the vehicle is parked for long periods of time, gasoline evaporation occurs as the temperature rises during the day.
- Refueling—Gasoline vapors escape from the vehicle's fuel tank while the tank is being filled.

Source: U.S. Environmental Protection Agency, Automobile Emissions: An Overview, Fact Sheet OMS-5, August 1994, <http://www3.epa.gov/otaq/consumer/05-autos.pdf>

What Are the Emissions from a Typical Drive in My Car?

Average Emissions of a Typical Car on the Road in 2015



Source: U.S. Environmental Protection Agency, MOVES2014 model run, assumed summer weekday for VOC and NO_x, winter weekday for CO, June 2015

Starting a car cold increases trip emissions compared to starting an engine that is already warm. On a given weekday, cold starts of a typical vehicle produce 2.4 grams of VOCs (25 percent of the typical daily emissions), 24.2 grams of CO (28 percent of the typical daily emissions), and 2.4 grams of NO_x (24 percent of the typical daily emissions) per vehicle start. Running exhaust accounts for another 2.2 grams of VOCs, 61.9 grams of CO, and 7.6 grams of NO_x per mile traveled.

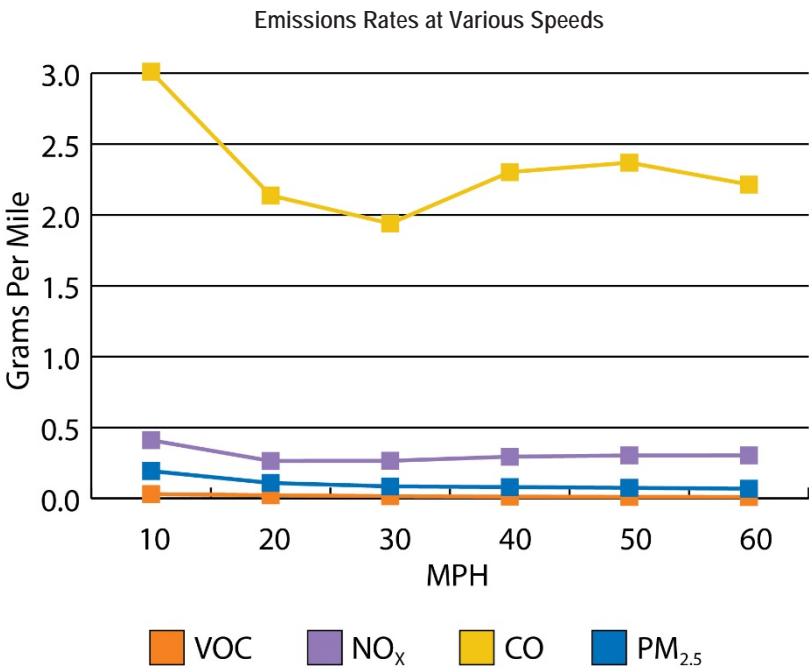
VOCs are also emitted through fuel evaporation. For example, parking your car all day produces about 3.8 grams of VOCs.

Source: U.S. Environmental Protection Agency, MOVES2014 model run, assumed summer weekday for VOC and NO_x, winter weekday for CO, June 2015, <http://www3.epa.gov/otaq/models/moves/index.htm>

Do Vehicle Emissions Rates Change with Vehicle Speed?

Emissions rates vary based on the speed a vehicle is traveling. EPA's model for highway vehicle emissions, Motor Vehicle Emission Simulator (MOVES), shows how speed affects emissions rates. VOC, NO_x, CO, and PM_{2.5} emissions rates are typically higher at lower speeds (0-20 mph).

These curves do not represent the full range of effects associated with travel at different speeds. Emissions rates are higher during stop-and-go, congested traffic conditions than free-flow conditions operating at the same average speed.

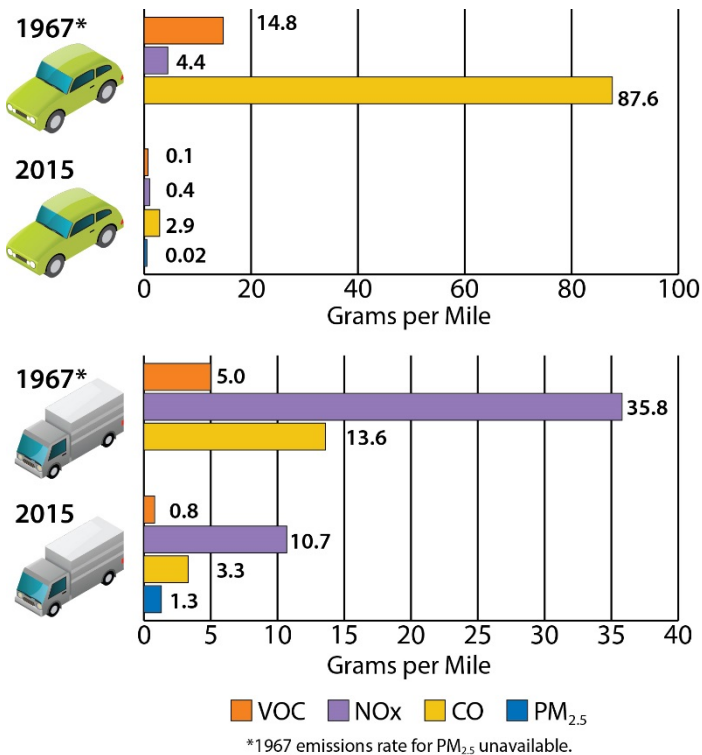


Sources: U.S. Environmental Protection Agency, MOVES2014 model run, assumed summer weekday for VOC and NO_x, winter weekday for CO, June 2015, <http://www3.epa.gov/otaq/models/moves/index.htm>

How Have Car and Truck Emissions Changed since the Clean Air Act?

The comparisons below show estimated in-use emissions rates, in grams per mile, for cars and heavy-duty diesel trucks with 2015 control technology versus 1967 vehicles (before significant emissions controls). The 1967 rates are based on EPA's previous emissions model, MOBILE6.2, while the 2015 rates are derived from EPA's newer MOVES model.

Car and Truck Emissions



Car emissions rates have declined by more than 90 percent depending on the pollutant, while heavy-duty diesel truck emissions rates have declined by 84 percent for VOCs, 70 percent for NO_x, and 76 percent for CO. Newer cars and trucks burn fuel much more efficiently now.

Sources: U.S. Environmental Protection Agency, MOVES2014 model run, assumed summer weekday for VOC and NO_x, winter weekday for CO, June 2015, <http://www3.epa.gov/otaq/models/moves/index.htm>
 U.S. Environmental Protection Agency, MOBILE6.2 model run, March 2005

Policy Responses

Federal Policy Helping to Achieve Our Clean Air Standards

Despite continued improvements, the air quality issues facing states and regions require that policymakers consider strategies to reduce emissions from all sources—point and area, on-road mobile sources, and non-road engines. The efforts to achieve NAAQS and GHG reductions will require substantial emissions reductions over the next few decades and near zero emissions of CO₂ and other greenhouse gases by the end of the century. Implementing such reductions poses substantial technological, economic, social and institutional challenges. Multiple strategies are available to transportation and air quality officials ranging from regulatory to voluntary, and from technology- and fuel-based strategies to market-based measures aimed at changing driver behavior.

Transportation Conformity

Transportation conformity is a process to ensure that federal funding and approval are given to those transportation activities that are consistent with air quality goals. The conformity regulation requires that all transportation plans and programs in nonattainment or maintenance areas conform to the state's air quality plan, the SIP. It ensures that transportation activities do not worsen air quality or interfere with the purpose of the SIP, which is to attain the NAAQS for a criteria pollutant.

The conformity process requires state and local transportation officials to make tough decisions in order to meet both air quality and mobility goals. Where CAA goals were not being met, some state and local transportation officials have been challenged to find ways to reduce vehicle emissions by developing transportation plans, TIPs, and projects that will alter travel patterns, reduce the number of single-occupant vehicles, and make alternative modes of transportation (such as transit and bicycles) an increasingly important part of the transportation network.

Inspection and Maintenance Programs

Vehicle inspection and maintenance programs (I/M) help improve air quality by identifying high-emitting vehicles in need of repair (through visual inspection, emissions testing, and/or the downloading of information from a vehicle's onboard computer) and causing them to be fixed as a prerequisite to vehicle registration within a given nonattainment area. A high-emitting vehicle is one which is emitting at some increment above the standard to which it was certified, either 2-3 times the standard for vehicles being tailpipe tested, or 1.5 times the standard for vehicles equipped with onboard diagnostic (OBD) systems and subject to the OBD test. The CAAA made I/M mandatory for several areas across the country, based upon various criteria, such as air quality classification, population, and/or geographic location.

A small percentage of vehicles emit a large percentage of the pollution from on-road vehicles. These gross emitters include not only older-model cars, but also some new cars with poorly maintained or malfunctioning emissions-control equipment.

Previous studies estimated that less than 10 percent of a vehicle fleet emits approximately 50 percent of the VOC emissions in a region. The same vehicles, however, are not always gross emitters for all criteria pollutants; a different 10 percent of vehicles may be gross emitters for CO, NO_x, and others. Additionally, 10 to 27 percent of the vehicles failing inspection subsequently do not ultimately pass state inspection and maintenance tests. Several states have implemented vehicle scrappage or vehicle exchange programs to remove these types of vehicle from their fleet in nonattainment areas.

Improvements in Vehicle Technology and Fuels

Numerous alternatives and improvements to vehicle technology and fuels have been directed and/or promoted by Federal policy in the last two decades.

Diesel Engine Retrofits

Diesel engine retrofit programs have been funded and implemented over the last decade. Several retrofit emissions-control technologies are available with varying levels of demonstrated effectiveness at reducing PM, VOCs, CO, and air toxics. The diesel particulate filter has the potential to reduce particulates to near zero. Advanced diesel oxidation catalysts result in less dramatic reductions but are less expensive and can run on diesel with higher sulfur levels. Various fuel additives can also help reduce emissions of some pollutants compared to regular diesel fuel.

Emissions can be reduced by using fuels with certain properties or by using alternative fuels. Ultra-low sulfur diesel (ULSD) fuel as well as biodiesel blends will reduce emissions. Engines certified to operate on alternative fuels such as liquefied petroleum gas (LPG), compressed natural gas (CNG), and liquefied natural gas (LNG) can also reduce emissions.

Heavy-Duty Diesel Truck Idling Reduction

Projects that reduce continuous idling of heavy-duty diesel truck engines at truck stops provide electric power for cab space cooling and heating, as well as other amenities, such as Internet access and television viewing. Several technologies are available to reduce idling including direct-fired heaters, auxiliary power units, automatic engine idle management systems, and truck stop electrification. Idle-reduction measures can help meet multiple goals, including energy conservation, energy security, and environmental stewardship.

Vehicle Aerodynamics

Improving vehicle aerodynamics is one way to cut fuel consumption and emissions. Aftermarket fairings attached to the front and/or belly of truck trailers can improve fuel efficiency by up to six percent. There are also modifications to the tractor that can improve fuel economy, such as upgraded front bumpers, air dams, and side mirrors. Roof fairings, cab extenders, and side fairings installed on a tractor can achieve fuel savings of up to 600 gallons per year and emissions reductions of over five metric tons of GHGs. Similarly, covering empty rail cars, modifying how intermodal cars are loaded, and minimizing open areas between cars can help improve train aerodynamics.

SmartWay Transport

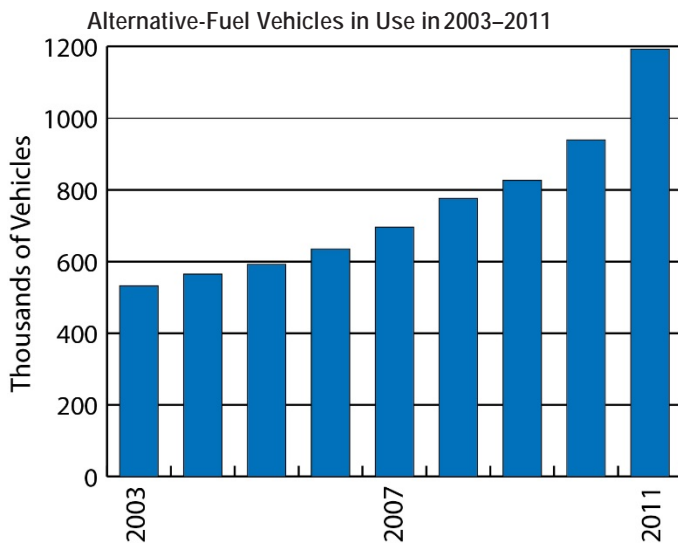
EPA's SmartWay Program is a public-private initiative to reduce greenhouse gas emissions and air pollution created by freight transportation. SmartWay Transport is comprised of partnerships, policy and technical solutions, and research and evaluation projects that find new ways to optimize the transportation networks in a company's supply chain. Participating companies use performance-based quantification and reporting tools that benchmark and inform industry and the marketplace on freight operations, energy, and environmental efficiency.

Sources: The Intergovernmental Panel on Climate Change, http://www.ipcc.ch/pdf/assessment-report/ar5/syr/AR5_SYR_FINAL_SPM.pdf
U.S. Environmental Protection Agency, <http://www3.epa.gov/otaq/diesel/technologies/fuels.htm>
FHWA, Freight and Air Quality Handbook, May 2010, <http://www.ops.fhwa.dot.gov/publications/fhwahop10024/index.htm>
U.S. Department of Energy, Energy Information Administration, Alternative Fuel Vehicle Data, November 2015, <http://www.afdc.energy.gov/fuels/>
U.S. Energy Information Administration, March 2015 Monthly Energy Review, Table 10.2b Renewable Energy Consumption: Industrial and Transportation Sectors, April 2015, http://www.eia.gov/totalenergy/data/monthly/pdf/sec10_5.pdf
U.S. Department of Energy, Alternative Fuels Data Center, <http://www.afdc.energy.gov/fuels/biodiesel.html>
U.S. Environmental Protection Agency, SmartWay Transport Overview, EPA-420-F-15-033, July 2015, <http://www3.epa.gov/smartway/about/documents/basics/420f15033.pdf>

Alternative-FuelforVehicles

A variety of alternative fueled vehicles are effective in reducing emissions:

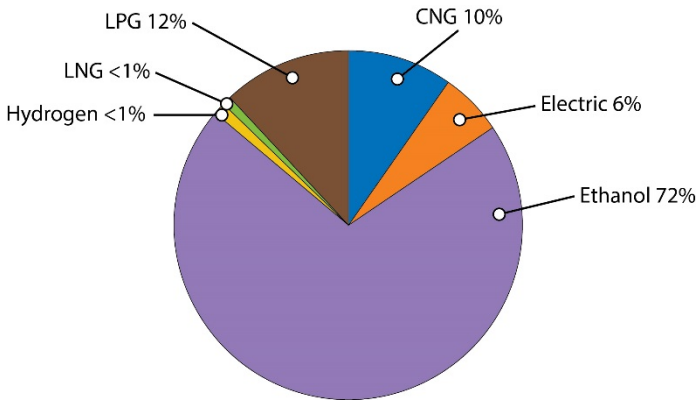
- Liquefied petroleum gas (LPG)—a fossil-fuel derivative composed of 95 percent propane and 5 percent butane. It produces lower CO emissions, but NO_x emissions may be higher.
- Natural gas—a fuel that can be compressed (CNG) or liquefied. The CNG form, more common in the transportation sector, is stored in high-pressure cylinders. CNG generates lower CO and VOC emissions than conventional gasoline, and lower NO_x and PM than diesel fuels.
- Ethanol—grain alcohol made from corn, sugarcane, or woody biomass. Ethanol blends may reduce CO emissions, but their effect on O₃ is negligible due to increases in NO_x.
- Electricity—Electric vehicles may be powered by batteries either charged at home or at charging stations with electricity from power plants. They have no tailpipe emissions; overall emissions depend on power plant energy sources.
- Hydrogen—Two types of engines burn hydrogen. One is an internal combustion engine; the other is a fuel cell. Hydrogen is a clean-burning fuel that can be produced from coal, natural gas, petroleum, solar, or wind energy. A vehicle operating on a fuel cell, which generates electricity by harnessing the reaction of hydrogen and oxygen to make water, produces no CO or VOC emissions and extremely low NO_x emissions.



Source: U.S. Energy Information Administration, <http://www.afdc.energy.gov/data/>

Use of alternative fuels for motor vehicles has increased in recent years. Nearly 1.2 million alternative-fuel vehicles (AFVs) were on the road in 2011, a 124 percent increase since 2003. The American Recovery and Reinvestment Act of 2009 supported a variety of alternative fuel and advanced vehicle technologies through grant programs, tax credits, research and development, fleet funding, and other measures.

Share of Alternative-Fuel Vehicle by Fuel Type in 2011



Sources: U.S. Energy Information Administration, Archive—Alternative Transportation Fuels (ATF) and Alternative Fueled Vehicles (AFV), March 2015, <http://www.afdc.energy.gov/data/>

AFVs designed to operate on ethanol were the most popular in 2011, followed by LPG, CNG, and electricity.

Automated Vehicles/Connected Vehicles

Automated vehicles/connected vehicles (AVCVs) are those in which at least some aspect of a safety-critical control function (e.g., steering, throttle, or braking) occurs without direct driver input. AVCVs may be autonomous (i.e., use only vehicle sensors) or may be connected (i.e., use communications systems such as connected vehicle technology, in which cars and roadside infrastructure communicate wirelessly).

AVCVs have the potential to bring about transformative safety, mobility, energy, and environmental benefits to our nation's surface transportation system. These benefits could include reduced energy consumption and vehicle emissions, reduced travel times, improved travel time reliability and multi-modal connectivity, and improved transportation system efficiency and accessibility.

Source: U.S. Department of Transportation, Intelligent Transportation Systems Joint Program Office, October 2015, http://its.dot.gov/automated_vehicle/index.htm

Transportation Control Measures

States and localities can help reduce motor vehicle emissions by implementing measures to manage travel demand or improve traffic flow.

Under the Transportation Conformity Rule, Transportation Control Measures (TCMs) are strategies that are specifically identified and committed to in State Implementation Plans (SIPs); and are either listed in Section 108 of the CAA or will reduce transportation-related emissions by reducing vehicle use or improving traffic flow. Measures that reduce emissions by improving vehicle technologies, fuels, or maintenance practices are not TCMs.

Alternatives to Driving Alone

TCMs that focus on providing alternatives to single-occupant vehicle travel, such as carpooling, transit, and bicycling, include:

- Bicycle/pedestrian facilities—provision of paths, special lanes, lockers, showers, or other facilities.
- Area-wide ridesharing—a program that provides carpool matching and information services.
- Park-and-ride facilities—parking lots or facilities located to provide access to transit stations, high-occupancy vehicle lanes, or bus services, or to encourage carpooling.
- Improved public transit—infrastructure improvements, including system expansion, provision of new expanded services, and financial incentives to use existing transit services, such as special fare programs to entice riders.

Improving Traffic Flow

Traffic flow improvements focus on reducing stop-and-go traffic conditions through:

- Intelligent transportation system (ITS)—a system of information technologies and electronics that are applied to the transportation network. These technologies include the latest in computers, electronics, communications, and safety systems. Some of the more common applications include:
 - Freeway management.
 - Transit management.
 - Incident management and emergency response.
 - Electronic toll collection and electronic fare payment.
 - Railroad crossings.
 - Regional multimodal traveler information.

- High-occupancy vehicle lanes—highway lanes reserved for high-occupancy vehicles such as buses, vanpools, and carpools.
- Signal timing improvements—intersection signal light changes to enhance the flow of vehicles on arterials.

Freight Improvements

Policymakers employ a variety of operational and system management strategies to reduce freight vehicle emissions. These take the form of local regulations and ordinances, congestion mitigation efforts geared towards speeding the flow of freight, and operational changes to reduce emissions. Some of the most common approaches include:

- Idle reduction technologies and strategies that reduce emissions by cutting down on the time freight vehicles spend idling, including truck stop electrification.
- Arterial signal coordination on routes with high truck traffic—adjusting signal timing to optimize traffic flow on routes with a high percentage of trucks.
- Port access improvements—projects and technologies that enhance main access routes to seaports (either road or rail) can reduce emissions by minimizing wait times and queuing at the gates.
- Truck-only lanes—some states have experimented with freeway lanes wholly or partially devoted to trucks. By separating trucks from other traffic, truck-only lanes improve traffic flow and enhance safety.

Market-Based Measures

Measures that rely on pricing as an incentive to reduce travel congestion include:

- Parking pricing—increases in parking fees or reduced fees for carpools.
- Parking cash-out/transit subsidies—a program in which employees are given the option of taking the cash value of a parking space or a transit subsidy instead of free parking at their job site.
- Managed lanes—designated lanes in roadways that assess road charges with increased price during hours of peak demand.
- Emissions/VMT taxes—vehicle registration fees based on emissions rates and/or miles driven.
- Fuel taxes—taxes paid at the pump on motor vehicle fuels.

Help from Businesses

Employers help implement measures to reduce single-occupant vehicle travel, including:

- Compressed workweeks—extension of the typical workday in order to reduce the number of days worked, thereby reducing the number of work trips.
- Telecommuting—arrangements allowing employees to work at home or at satellite offices close to home.
- Commuter choice—benefits that employers can offer employees to commute to work by methods other than driving alone. These may include “qualified transportation fringes” under Internal Revenue Service rules, such as transit and vanpool vouchers, biking, walking, teleworking, and others.

Other Measures

Other measures to reduce congestion and emissions include:

- Episodic—measures that are put in place during days when air quality is expected to be poor to reduce exceedances of air quality standards, such as Ozone Action Days.
- Land use planning—incentives and planning to encourage development patterns that place jobs, housing, and services closer together and that encourage pedestrian and transit-friendly environments. Transit-oriented development is an example of this technique.
- Parking restrictions—parking policies that discourage vehicle use, such as time restrictions and/or elimination of on-street parking.
- Car sharing—programs for people to use a shared vehicle for a short period of time, allowing users access without the fixed costs and responsibilities of ownership.
- Bike sharing—programs that provide bicycles for shared use and rented on an as-needed basis, allowing users access without the fixed costs and responsibilities of ownership.

Program Funding

Numerous sources are available to fund measures that reduce transportation-related emissions, including traditional funding sources, state and local sources, user fees, and private-sector resources.

One major source of funds, the Congestion Mitigation and Air Quality Improvement Program (CMAQ), was established under the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA) and reauthorized under each subsequent transportation bill since, including the Fixing America’s Surface Transportation Act (FAST Act).

The CMAQ program allocates funds to states to implement transportation projects, including TCMs, and other strategies to help nonattainment and maintenance areas meet the NAAQS for O₃, CO, and PM. The actual amount of funding is based on the severity of the air quality problem and the population of the area. State and local governments select the projects to fund and coordinate them through metropolitan planning organizations. Eligible strategies include:

- Transit improvements.
- Alternative-fuels and vehicles.
- Shared-ride services.
- Traffic flow improvements.
- Demand management strategies.
- Pedestrian and bicycle programs.
- Inspection and maintenance programs.
- Diesel retrofits and idle reductions.

EPA offers funding for projects that reduce diesel emissions from existing engines through the National Clean Diesel Campaign. Authority for Clean Diesel funding comes from the Diesel Emissions Reduction Act (DERA), part of the Energy Policy Act of 2005. Seventy percent of the DERA appropriation is to be used for national competitive grants and rebates to fund projects that use EPA or California Air Resources Board (CARB) verified or certified diesel emissions reduction technologies.

Thirty percent of the DERA appropriation is allocated to the states and territories to fund programs for clean diesel projects. In the past ten years, \$1.8 billion in funding has been allocated to these programs.

WHERE CAN I GET MORE INFORMATION?

Where Can I Get More Information?

U.S. Department of Transportation (DOT)

<https://www.transportation.gov/>

U.S. DOT, Federal Highway Administration (FHWA), Planning, Environment and Realty

<http://www.fhwa.dot.gov/hep/>

U.S. DOT, Federal Highway Administration (FHWA), Office of Highway Policy Information

<http://www.fhwa.dot.gov/policyinformation/index.cfm>

U.S. DOT, Federal Transit Administration (FTA)

<http://www.fta.dot.gov/>

U.S. DOT, Bureau of Transportation Statistics (BTS)

<http://www.rita.dot.gov/bts/home>

U.S. DOT, Transportation and Climate Change Clearinghouse (TCCC)

<http://www.climate.dot.gov/index.html>

U.S. Environmental Protection Agency (EPA)

U.S. EPA, Office of Air and Radiation

<http://www3.epa.gov/air/>

U.S. EPA, Office of Air Quality Planning and Standards

<http://www3.epa.gov/airquality/>

U.S. EPA, Office of Transportation and Air Quality

<http://www3.epa.gov/otaq>

U.S. EPA, Climate Change Site

<http://www3.epa.gov/climatechange/>

Other Government Agencies

U.S. Department of Energy (DOE), Energy Information Administration (EIA)

<http://www.eia.gov/>

U.S. Census Bureau

<http://www.census.gov/>

Oak Ridge National Laboratory, Center for Transportation Analysis

<http://cta.ornl.gov/cta/>



U.S. Department of Transportation
Federal Highway Administration

Office of Natural Environment
1200 New Jersey Avenue SE
Washington, D.C., 20590
http://www.fhwa.dot.gov/environment/air_quality/

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