Air Quality Trends in North Carolina

December 2018

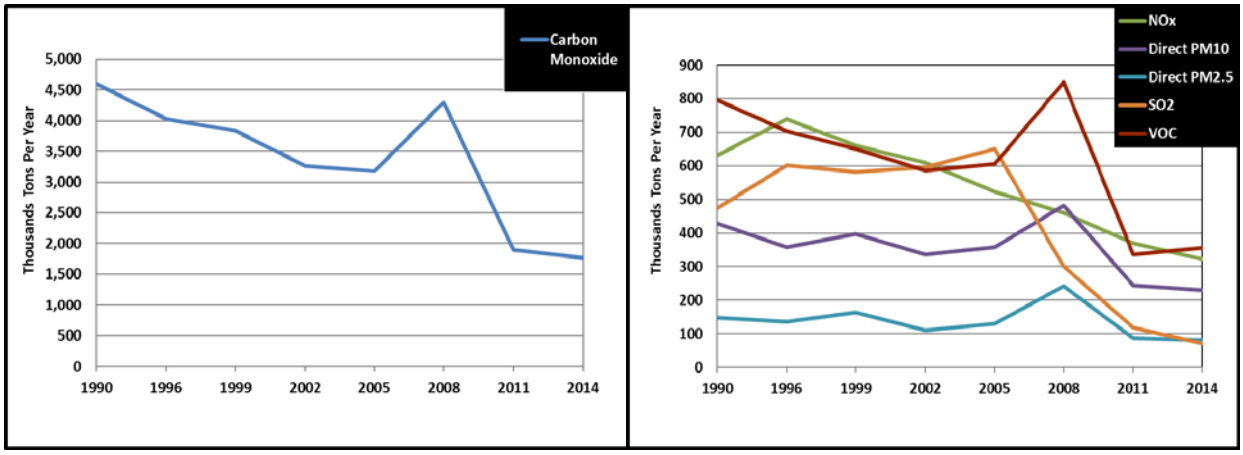
Air Pollutant Emissions Trends in North Carolina

N.C. Division of Air Quality, December 2018

Criteria Air Pollutants

North Carolinians are breathing the cleanest air in decades. State leaders, regulatory agencies, electric utilities, industry, and the public have significantly addressed air quality concerns in recent years. Their collective efforts are achieving impressive results to reduce tropospheric ozone and particulate matter (PM) pollution. From 1990 through 2014, statewide emissions of sulfur dioxide (SO_2) declined 85%, carbon monoxide (CO) by 62%, oxides of nitrogen (NOx) by 49%, PM by 46%, and volatile organic compounds (VOC) by 55%.

Annual Statewide Criteria Air Pollutant Emissions*



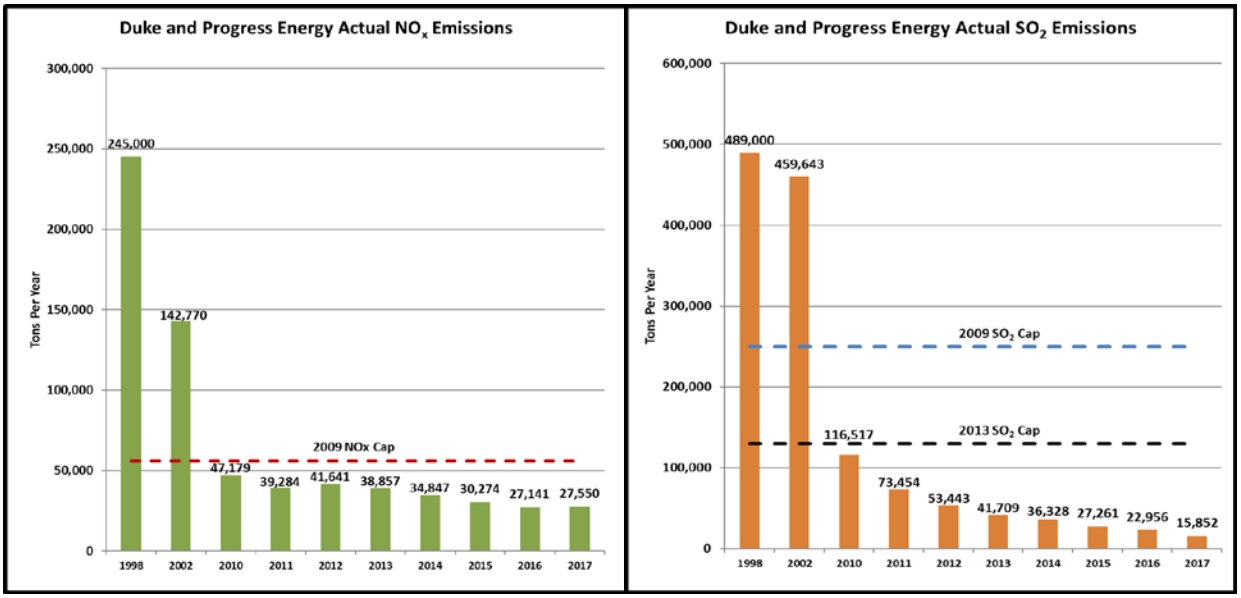
*A significant wildfire event occurred in 2008 that substantially increased CO, PM, and VOC emissions. Direct PM10 and PM2.5 represent small particles of particulate matter with an aerodynamic diameter less than or equal to 10 and 2.5 micrometers, respectively.

For example, harmful emissions from coal-fired electricity generating units (EGUs) operating in North Carolina were significantly reduced following passage of the Clean Smokestacks Act in 2002 (see the "Clean Smokestacks Act Emissions Reductions" chart on page 3). From 2002 through 2017, coal-fired EGUs subject to this legislation reduced total NOx and SO_2 emissions by 115,200 tons (81%) and 443,792 tons (97%), respectively. The state's coal-fired EGUs are among the most efficient and least polluting in the nation. Also, since 2005, the state significantly transitioned to cleaner burning natural gas for electric power generation and has continued to increase its renewable energy capacity under the Southeast's only Renewable Energy and Energy Efficiency Portfolio Standard. This transition reduced North Carolina's coal consumption in the electric power generation sector's fossil fuel mix by approximately 56% and assisted the state to become second in the nation for solar photovoltaic capacity.

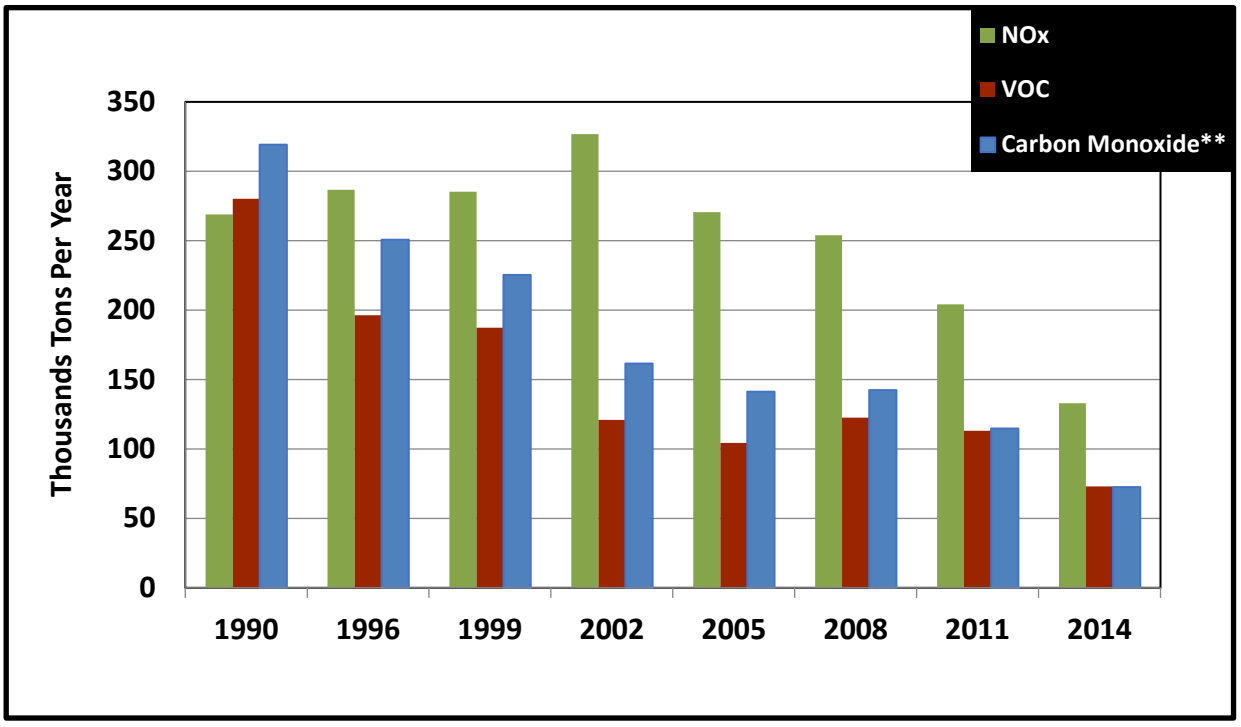
Transportation emissions associated with everyday operation of passenger vehicles and trucks have also declined significantly (see the "Onroad Mobile Source Emissions Reductions" chart on page 3). From 1990 through 2014, CO, NOx, and VOC emissions have declined by 77%, 51%, and 74%, respectively. The decline in onroad emissions is associated with several on-the-books national rules that have been phased in over time, starting with the federal Tier 1 emissions standards from 1994-1999, national low-emissions vehicle standards from 1999-2003, Tier 2 emissions standards from 2004-2010, and heavy-duty vehicle standards

from 2007-2010. Further reductions are expected to occur in the future under the Tier 3 vehicle emissions and fuel standards from 2017-2025. As a result of these standards, North Carolina's vehicle fleet has become cleaner as newer low-emitting vehicles replace older higher-emitting vehicles, and the emissions controls on the vehicles are more technologically advanced - thus lasting longer and less prone to malfunctions or failures.

Clean Smokestacks Act Emissions Reductions



Onroad Mobile Source Emissions Reductions*

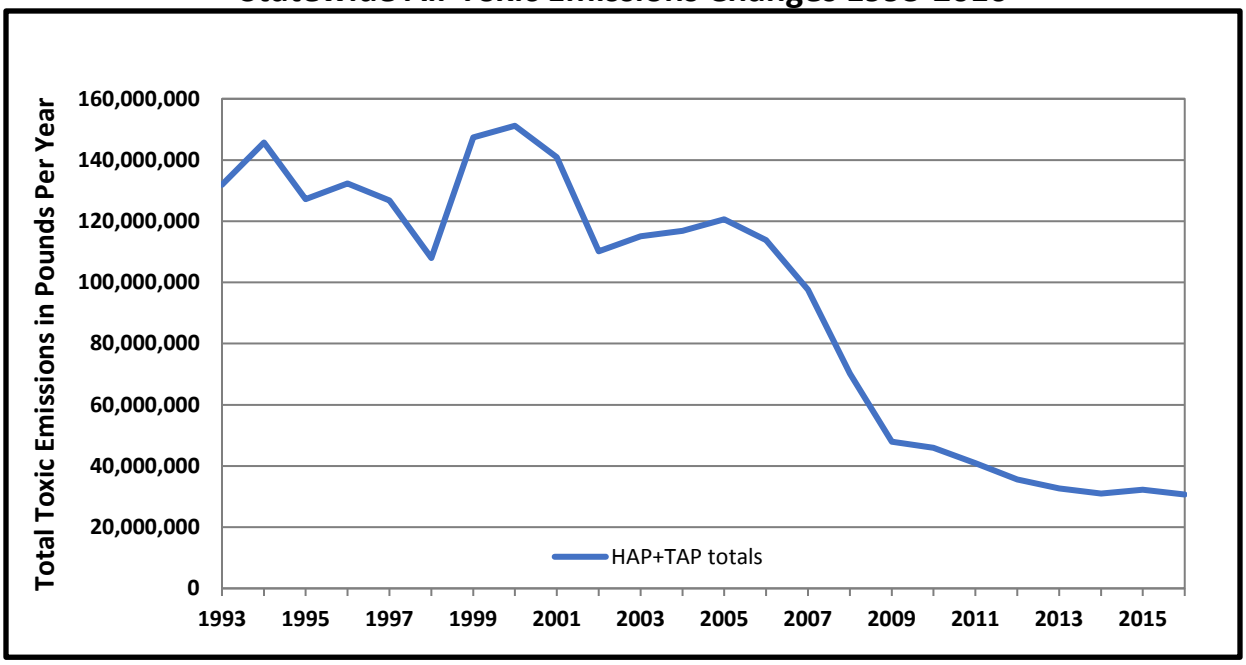


** The NOx emissions spike in 2002 is attributed to EPA adjusting the onroad emissions model.*
*** CO emissions represented in this chart were divided by a factor of 10 for comparability purposes.*

Air Toxics

Industry implemented several measures to reduce their hazardous air pollutant (HAP) and toxic air pollutant (TAP) emissions. These include upgrading processes with advanced valve seals, leak detection systems, and state-of-the-art control technologies. Where practical, the use of hazardous chemicals in manufacturing processes have been eliminated or reduced. Also, the state is working alongside the Secretaries' Science Advisory Board (SAB), EPA, and academic researchers to find solutions for the scientific uncertainties of GenX and other emerging compounds. This process involves researching atmospheric deposition, environmental fate and transport, health-based inhalation risks, and the utilization of control technologies to improve ambient air quality.

Statewide Air Toxic Emissions Changes 1993-2016



HAP = Federal hazardous air pollutants.
TAP = North Carolina-specific toxic air pollutants.
Source: North Carolina point source inventory.

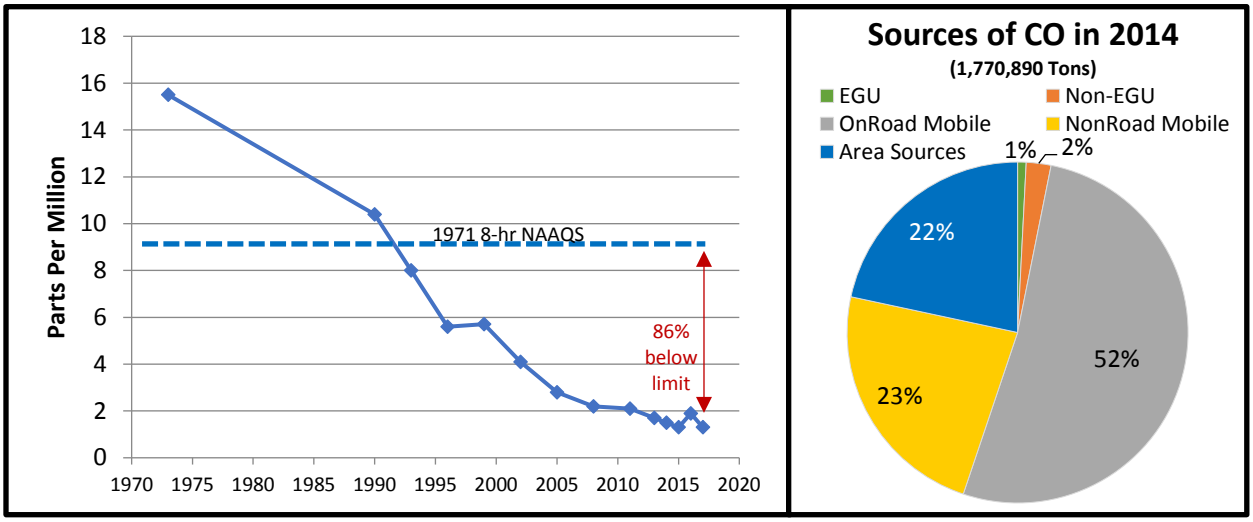
Ambient Air Improvements

Air quality and visibility substantially improved across North Carolina. In the past, extensive portions of North Carolina had tropospheric ozone levels exceeding the health-based standard. The areas previously designated by the U.S. Environmental Protection Agency (EPA) as not meeting air quality standards included more than 30 counties in the Charlotte, Fayetteville, Rocky Mount, Triad, and Triangle metropolitan areas, and the Great Smoky Mountains National Park. Today all areas of the state qualify as attaining the National Ambient Air Quality Standards (NAAQS) established by EPA for the protection of public health and the environment. The subsequent charts show ambient concentration trends and 2014-year emissions for CO, lead (Pb), nitrogen dioxide (NO_2), SO_2, ozone, PM, and visibility.

Carbon Monoxide

Improvements in exhaust controls, catalyst design, and fuel control systems have contributed to significant reductions in ambient CO concentrations. New cars, trucks, and non-road vehicles are about 99% cleaner for common pollutants (such as CO, NOx, PM, and VOCs) compared to 1970 vehicle models.[1] North Carolina no longer has any CO maintenance areas, and all areas of the state are attaining the 1971 8-hour NAAQS.

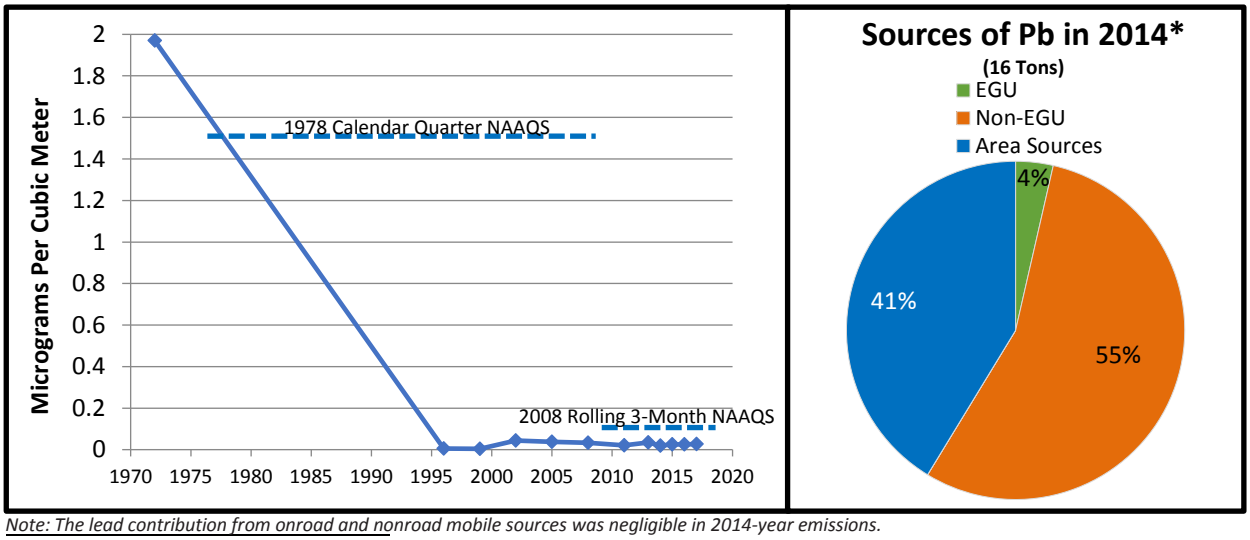
Statewide 8-hour Carbon Monoxide Levels



Lead

The phase-out of lead in motor vehicle gasoline pursuant to the Clean Air Act has led to dramatic reductions in airborne lead pollution and its adverse health effects. North Carolina is in statewide attainment of the 2008 lead NAAQS. In April 2016, North Carolina discontinued monitoring for lead because it is no longer required by EPA.

Statewide Lead Concentrations



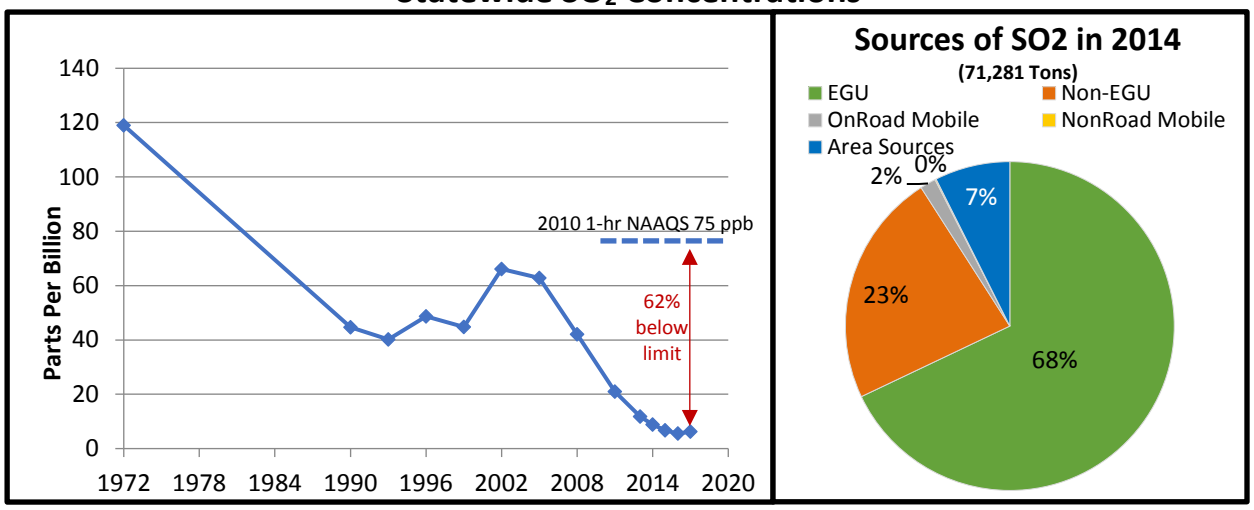
Note: The lead contribution from onroad and nonroad mobile sources was negligible in 2014-year emissions.

[1] "Progress Cleaning the Air and Improving People's Health." EPA, 22 Mar. 2018, www.epa.gov/clean-air-act-overview/progress-cleaning-air-and-improving-peoples-health.

Sulfur Dioxide

Lower sulfur content in fuel,[2] state-of-the-art scrubbers, and the increasing use of natural gas-fired combined-cycle EGUs have led to substantial reductions in SO_2 emissions. The EPA states that new coal-fired EGUs typically install control devices that capture up to 98% of SO_2 and in many cases 90% of NOx emissions, relative to uncontrolled levels.[3] For the 2010 1-hour SO_2 NAAQS, on December 21, 2017, EPA designated the vast majority of North Carolina as "Attainment/Unclassifiable" as a part of its Round 3 designation action pursuant to the Data Requirements Rule.[4] Brunswick County was designated "Unclassifiable" on June 30, 2016, as part of EPA's Round 2 action.[5] North Carolina is conducting source-oriented monitoring for three facilities in Buncombe, Haywood, and Person Counties, and EPA will use the monitoring data to complete its final Round 4 action by December 31, 2020.

Statewide SO_2 Concentrations

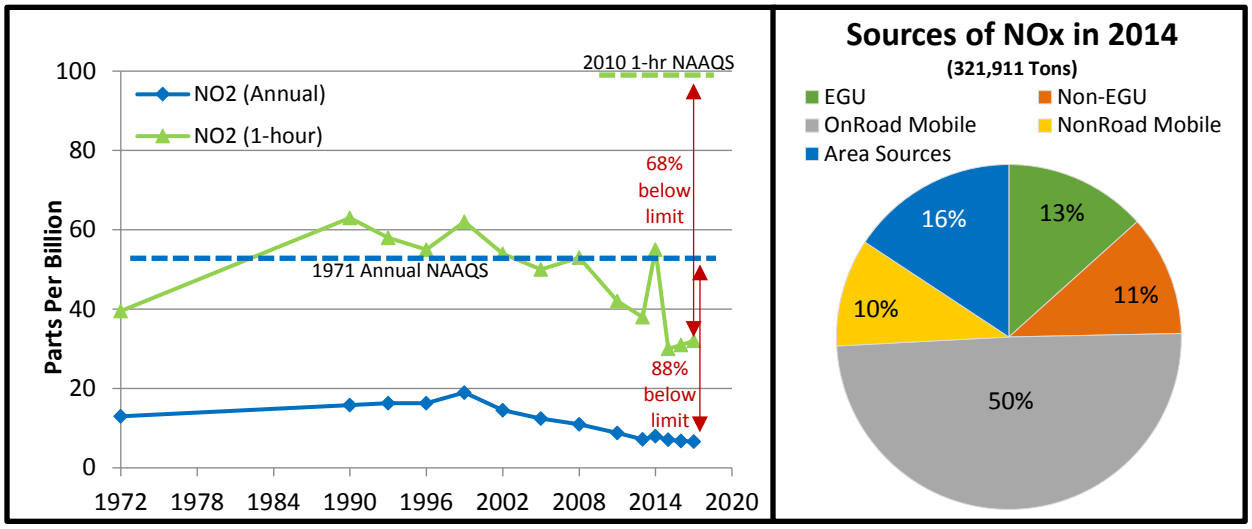


Nitrogen Dioxide

Improved vehicle emission standards, fuel efficiencies, ultra-low NOx burners, selective catalytic reduction (SCR), and selective non-catalytic reduction (SNCR) emission control technologies have contributed to substantial reductions in NOx emissions (see the "Statewide NO_2 Concentrations" chart on page 7). North Carolina is currently attaining both the 2010 1-hour and 1971 annual NO_2 NAAQS. Currently, there are 15 coal-fired EGUs across the state that are equipped with SCR controls, while 9 EGUs are equipped with SNCR.

[2] Since the 1960s, the sulfur content of gasoline and diesel fuel has dropped by 90% and 99%, respectively.
[3] EPA website, "Progress Cleaning the Air and Improving People's Health," https://www.epa.gov/clean-air-act-overview/progress-cleaning-air-and-improving-peoples-health#pollution, accessed Nov. 29, 2018. See section titled, "New power plants and factories use modern pollution control technology."
[4] 83 FR 1098, January 9, 2018.
[5] 81 FR 45039, July 12, 2016.

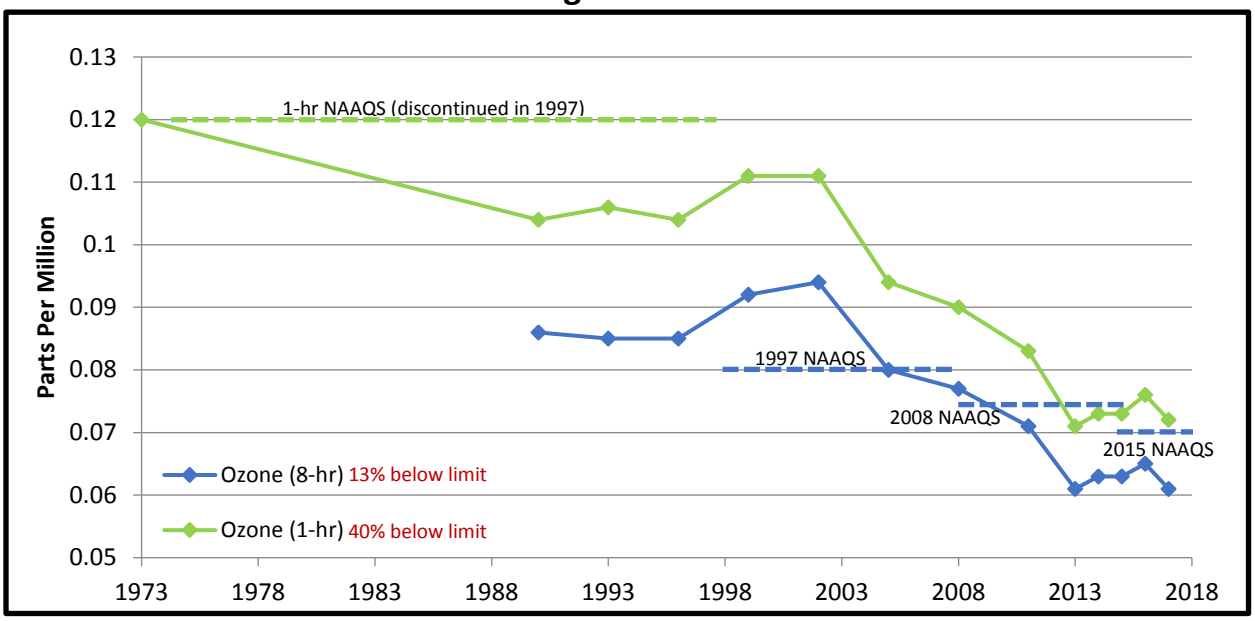
Statewide NO_2 Concentrations



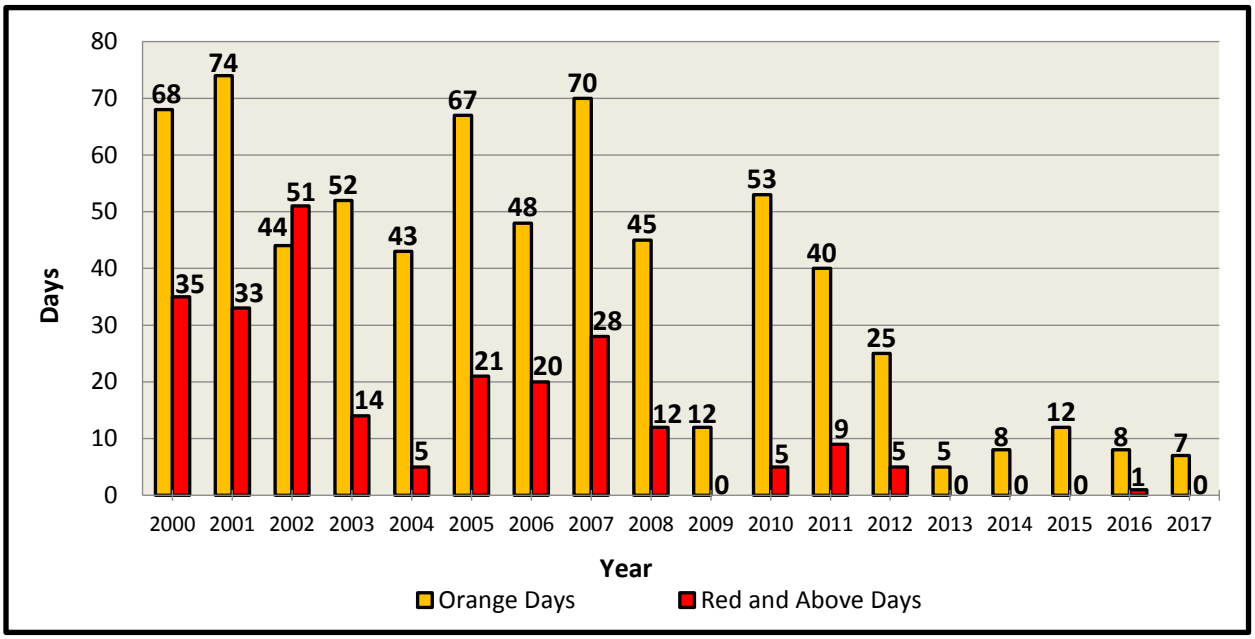
Ozone

Reductions in NOx emissions have markedly reduced tropospheric ozone formation. On October 1, 2015, the 2008 ozone standard was strengthened from 0.075 to 0.070 parts per million. On November 16, 2017, EPA designated North Carolina as attaining the 2015 ozone standard statewide. The number of ozone exceedances in North Carolina has declined since the more stringent standard was adopted by EPA in 2015 (see the "Statewide Ozone Exceedances (2015 Standard)" chart on page 8).

Statewide Average Ozone Concentrations



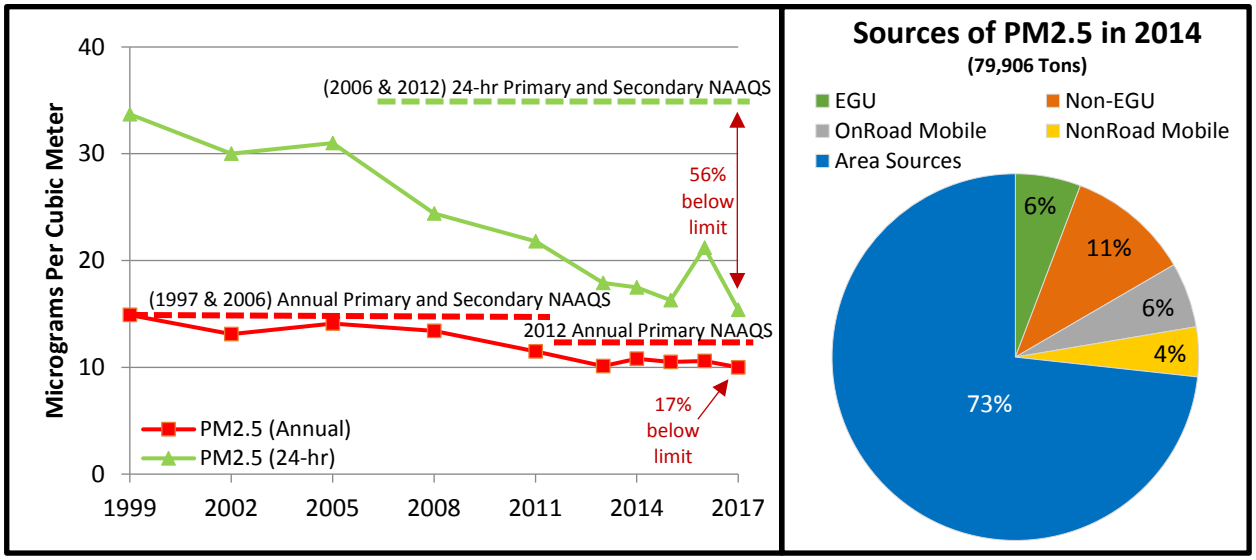
Statewide Ozone Exceedances (2015 Standard)



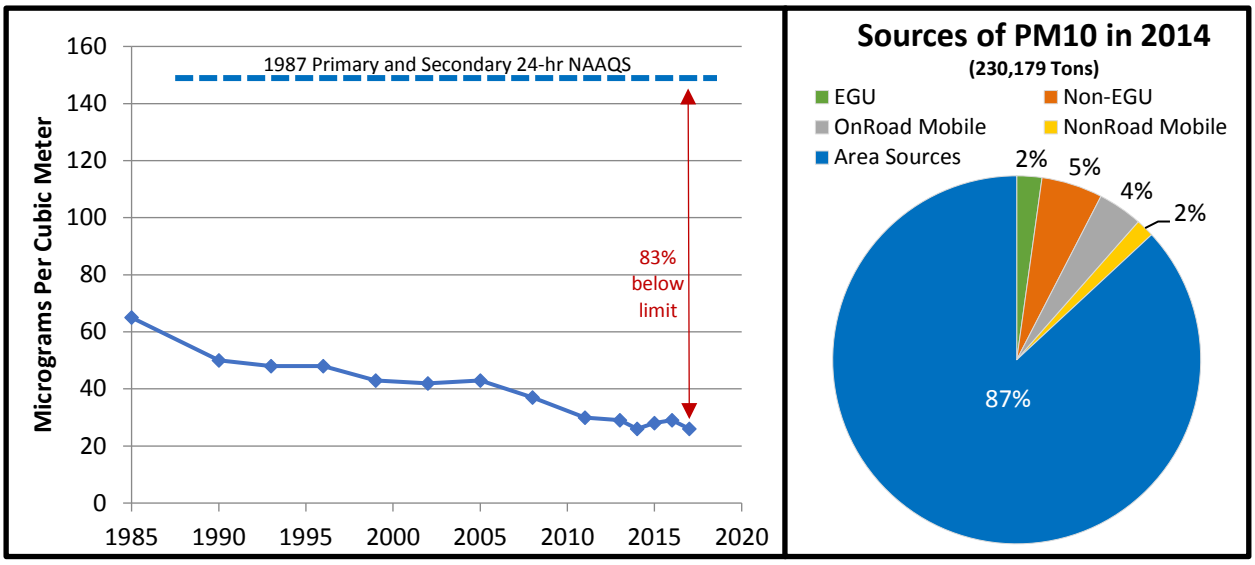
Particle Pollution

Reductions of NOx and SO_2 emissions from fossil fuel-fired EGUs, low-sulfur fuel standards, and mobile source PM have significantly lowered ambient $PM_{2.5}$ and PM_{10} concentrations across North Carolina.

Statewide $PM_{2.5}$ Concentrations

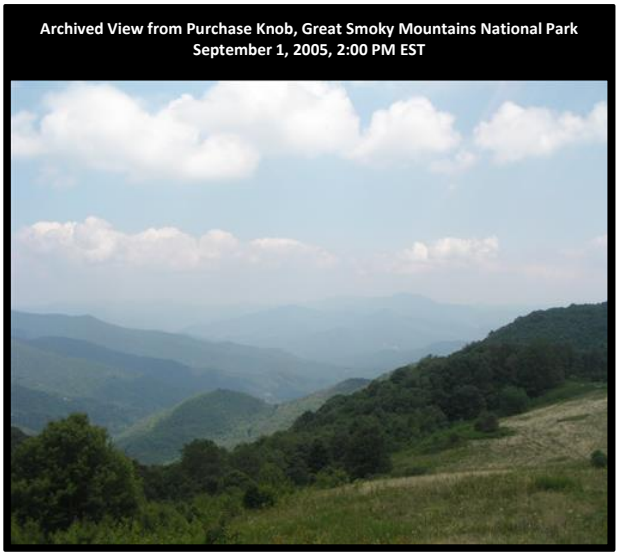


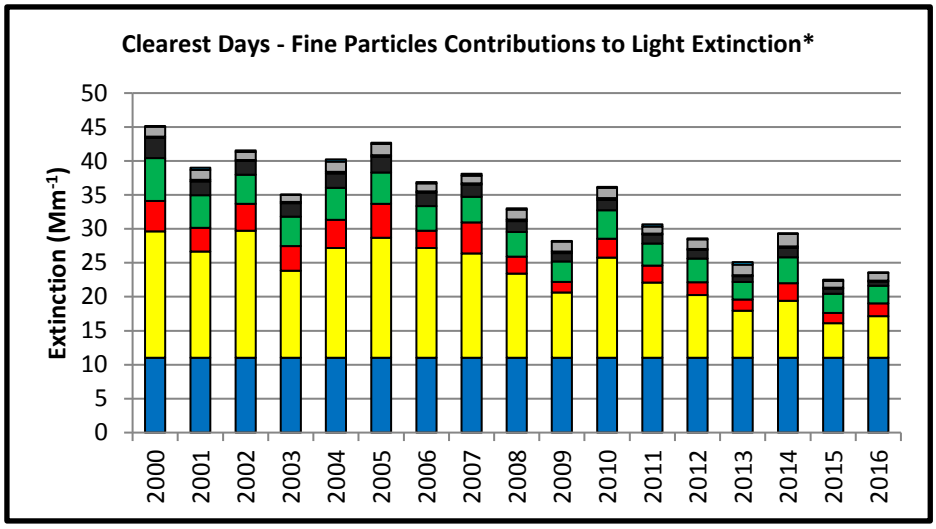
Statewide PM_{10} Concentrations

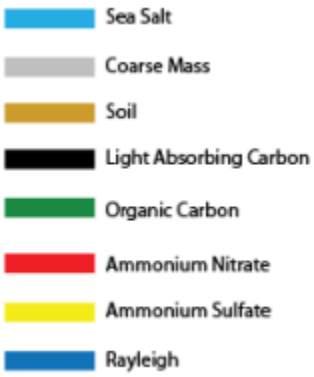


Visibility

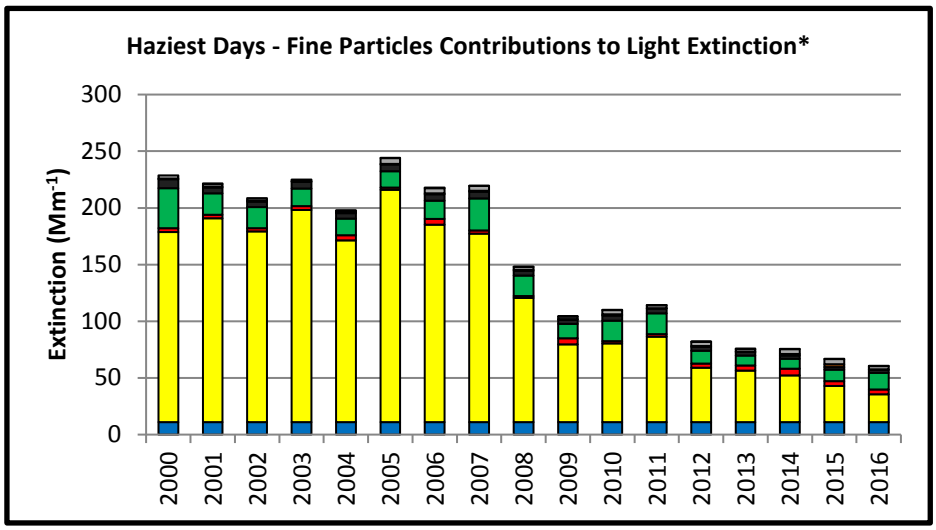
The scenic panoramas of our national and state parks are clearer due to reductions in SO_2 emissions and other air pollutants that scatter light. During hazy days, most light extinction is attributed to ammonium sulfate particles. However, the significant reduction of these fine particles resulted in better visibility for North Carolina's parks. For example, the photos below, which capture the clearest day of the month, show an increase in the viewshed distance from 2005 to 2016 from Purchase Knob in the Great Smoky Mountains National Park.







* Light extinction is expressed as inverse megameters (Mm^{-1}). Light extinction values for each year represent the annual average of the 20% clearest days as recorded by the Interagency Monitoring of Protected Visual Environments (IMPROVE) monitor for the Great Smoky Mountains National Park.



* Light extinction is expressed as inverse megameters (Mm^{-1}). Light extinction values for each year represent the annual average of the 20% haziest days as recorded by the IMPROVE monitor for the Great Smoky Mountains National Park.

The standard visual mile range on the haziest days
1996: 10 miles
2016: 41 miles

The standard visual mile range on the clearest days
1996: 54 miles
2016: 108 miles

Greenhouse Gas Emissions Trends in North Carolina

The collective efforts of state leaders, regulatory agencies, electric utilities, industry, and the public to control criteria air pollutant emissions to achieve statewide compliance with all the NAAQS have also yielded significant reductions in North Carolina's anthropogenic greenhouse gas (GHG) emissions. As shown in the following table, North Carolina's gross GHG emissions in 2017 are about 148 million metric tons of carbon dioxide equivalent emissions (MMT CO_2e).[6,7] Accounting for carbon sinks, North Carolina's net GHG emissions in 2017 are estimated at about 114 MMT CO_2e. From 2005 to 2017, North Carolina reduced its gross and net GHG emissions by 20% and 25%, respectively. During this same period, North Carolina's population and real Gross State Product grew by 18%.

North Carolina GHG Emissions Inventory by Source Sector (MMT CO_2e)

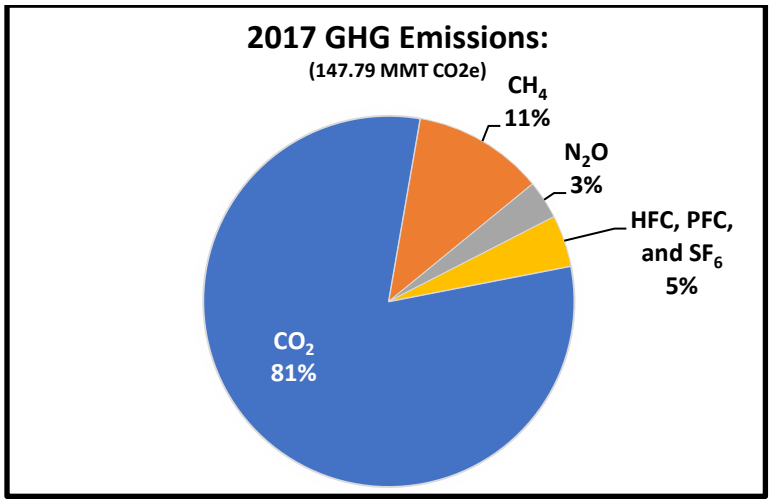
Sector	1990	2005	2012	2015	2017
Electricity Use	54.57	79.37	66.85	58.48	52.60
Residential/Commercial/Industrial Combustion*	26.77	26.02	18.66	21.15	20.92
Transportation	40.24	55.26	46.57	48.29	46.43
Agriculture	7.06	10.65	10.56	10.38	10.53
Waste Management	6.39	8.52	9.09	8.44	8.77
Industrial Processes	1.04	3.83	5.39	6.03	7.18
Natural Gas and Oil Systems	0.86	1.17	1.28	1.32	1.35
Gross Emissions**	**136.92**	**184.81**	**158.39**	**154.08**	**147.79**
Percent Reduction in Gross Emissions from 2005					**20%**
Net Carbon Sinks - Land Use, Land Use Changes and Forestry	-35.64	-32.66	-33.97	-34.16	-34.03
Net Emissions**	**101.28**	**152.14**	**124.42**	**119.92**	**113.76**
Percent Reduction in Net Emissions from 2005					**25%**

Note: Totals may not equal exact sum of subtotals shown in this table due to independent rounding.
* Represents emissions associated with on-site fuel combustion activities in the Residential, Commercial, and Industrial sectors.
** The inventory is presented as both gross emissions and net emissions (emissions minus carbon sinks) since targets for GHG emissions reductions are generally expressed as net emissions.

The six anthropogenic GHG pollutants included in the inventory are CO_2, methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF_6). The following chart shows the contribution of each gas type to North Carolina's total GHG emissions in 2017. Carbon dioxide is emitted in much larger amounts than the other GHGs combined; accounting for approximately 81% of the total GHG emissions in 2017. However, the global warming potential for the other GHGs, which incorporates both atmospheric lifetime and ability to trap heat, makes them significant contributors as well.

[6] North Carolina Greenhouse Gas Inventory DRAFT (1990 – 2030), North Carolina Department of Environmental Quality, Division of Air Quality, November 2018. 2015 is the last year of historic GHG emissions data. 2017 is a short-term projection of GHG emissions and is treated as historical data for this analysis.
[7] Emissions of each GHG pollutant are typically reported as MMT CO_2e which normalizes the emissions of the various GHG pollutants to reflect the global warming potential of each compound using CO_2 as a baseline.

Percentage of North Carolina's 2017 Gross GHG Emissions by Gas Type



The primary source of CO_2 emissions is fossil fuel combustion in the electricity generation; residential, commercial, and industrial fuel combustion; and transportation sectors. GHG emissions from fossil fuel combustion have decreased by 25% since 2005 due to both a shift in fuel use, from coal to natural gas, and increased energy efficiency. Methane emissions accounted for approximately 11% of the total GHG emissions in 2017. The primary sources of CH_4 are waste management and agriculture. Emissions from waste management and agriculture have not changed significantly since 2005, even with a growing population and economy.

Listed below are key findings from both the GHG emissions inventory and from the analysis of the data used to develop the emissions for each source sector. Emissions reductions are generally expressed as the percent change in gross GHG emissions, unless otherwise stated, from the baseline year of 2005 to 2017.

- **Electricity Generation**
  - Electricity generation is the largest emissions sector and represents 36% of all GHG emissions.
  - GHG emissions from electricity generation have decreased by 34% since 2005.
  - North Carolina's electricity generation sector has undergone a transformation since 2009 including;
    1) retirement of over 3,000 megawatts of coal fired EGUs, which is 25% of the NC coal fleet.
    2) increased use of efficient natural gas combined-cycle EGUs.
    3) North Carolina legislation to promote renewable energy.
  - Solar photovoltaic, hydroelectric, and wind power now represent 9% of North Carolina's electricity generation.
  - Avoided GHG emissions due to renewable energy power are estimated at 4 MMT CO_2e for 2017.
- **Transportation**
  - Transportation is the second largest emissions sector and represents 31% of all GHG emissions.
  - Emissions from the transportation sector have decreased by 16% from 2005 to 2017.
  - Gasoline represents 71% of the energy input into transportation while diesel represents 21%.

- **Residential, Commercial, and Industrial Fuel Combustion**
  - Residential, commercial, and industrial fuel combustion emissions represent over 20% of all GHG emissions.
  - Residential sector emissions from total energy use have decreased by 22% since 2005, while North Carolina's population grew by 18% over that time.
  - GHG emissions from fuel combustion in the commercial sector have increased by 13% due to shifts in the economy. This is offset by a 29% decrease in emissions from electricity use by this sector.
  - Industrial fuel combustion emissions have decreased by 30% since 2005.
  - GHG emissions from industrial processes have doubled since 2005.
- **Waste Management**
  - Many large landfills in North Carolina are now collecting CH_4 and using the captured biogas as energy, resulting in 561,000 megawatt-hours of electricity generation and an additional 149,000 million British thermal units of heat input in 2017.
  - There has been a 25% reduction in GHG emissions from this sector since 2005 primarily due to landfill gas energy recovery.
- **Land use, Land-Use Changes, and Forests**
  - Forests, natural lands, and agricultural lands sequestered an estimated 34 MMT of CO_2.
  - These carbon sinks are primarily due to increases in forest stocks and storage of carbon in wood products, reflecting North Carolina's increasing sustainable management of its forests and their economic uses.