Air Quality Trends in North Carolina

NORTH CAROLINA
Department of Environmental Quality

October 2020

Air Pollutant Emissions Trends in North Carolina

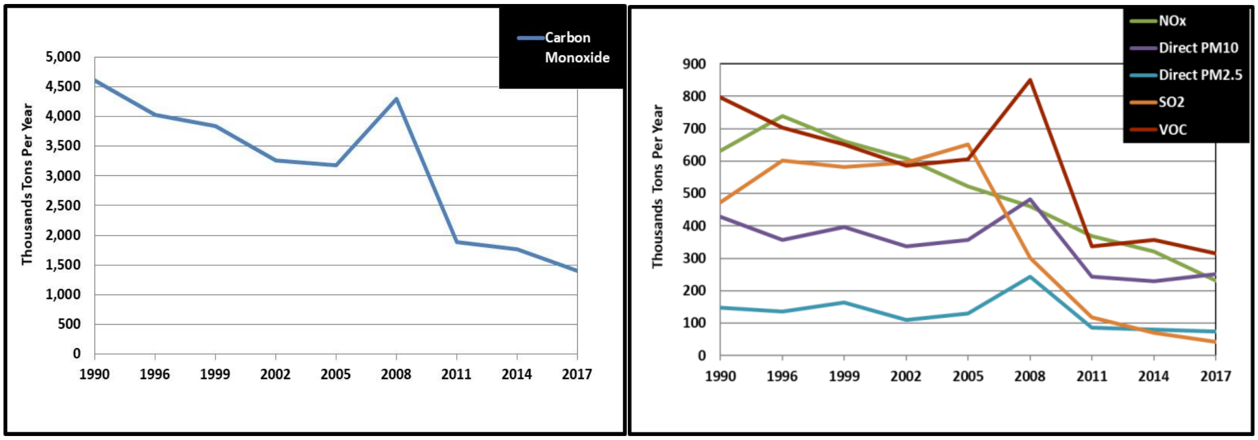
N.C. Division of Air Quality, October 2020

This report is an update to the previous report dated December 2018. For this update, criteria air pollutant emissions have been updated from 2014 to 2017, and ambient air concentrations have been added for 2018 and 2019. Air toxic emissions have also been updated from 2014 to 2017. Greenhouse gas (GHG) emissions are currently being updated by the North Carolina Division of Air Quality (DAQ) in Fiscal Year 2020-21, therefore, this report does not include any revisions to the previous report's GHG emissions. From 2014 through 2017, North Carolina has continued to show a general trend towards less air pollutant emissions. Note that the relative contribution of sector-level emissions to total emissions for a given pollutant may have changed from the previous report because of a higher reduction in pollutants for some sectors versus others.

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 2017, statewide emissions of sulfur dioxide (SO_2) declined 91%, carbon monoxide (CO) by 69%, oxides of nitrogen (NOx) by 63%, PM2.5 by 49%, and volatile organic compounds (VOC) by 60%.

Annual Statewide Criteria Air Pollutant Emissions*

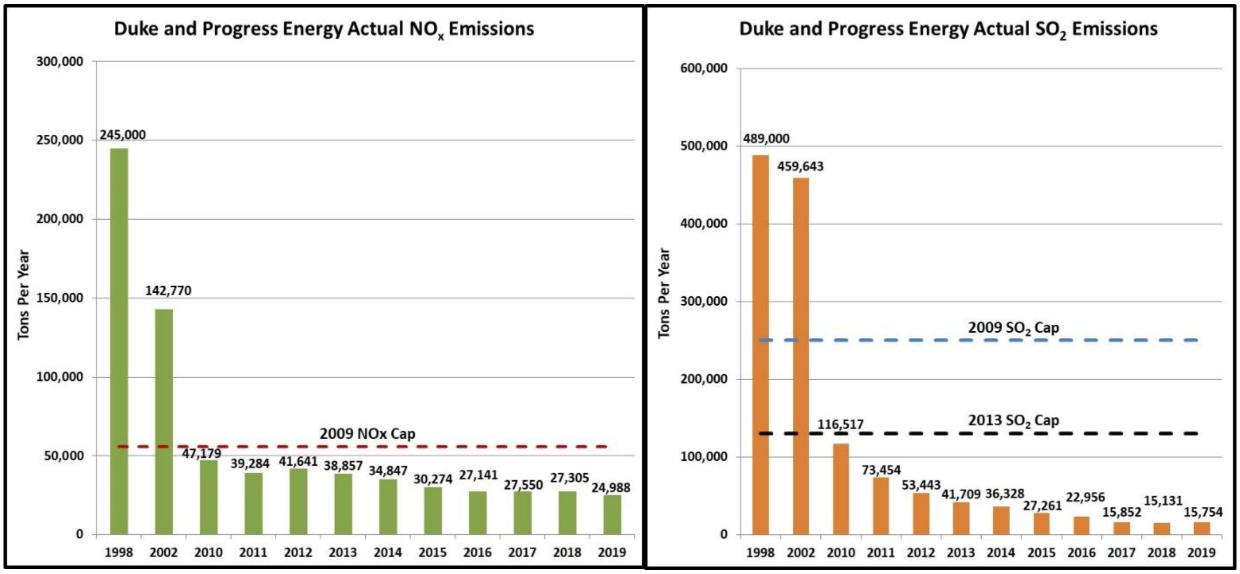


*A significant wildfire event occurred in 2008 that substantially increased CO, PM, and VOC emissions. Direct PM2.5 and direct PM10 represent small particles of particulate matter with an aerodynamic diameter less than or equal to 2.5 and 10 micrometers, respectively.

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 following "Clean Smokestacks Act Emissions Reductions" charts). From 2002 through 2019, coal-fired EGUs subject to this legislation reduced total NOx and SO_2 emissions by 117,782 tons (82%) and 443,889 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. While coal accounted for 96% of North Carolina's total fossil-fueled electricity generation in 2005, this figure dropped to only 47% in 2017.[1] The state has also transitioned to become second in the nation for solar photovoltaic capacity.[2]

Clean Smokestacks Act Emissions Reductions



Transportation emissions associated with everyday operation of passenger vehicles and trucks have also declined significantly (see the following "Onroad Mobile Source Emissions Reductions" chart). From 1990 through 2017, CO, NOx, and VOC emissions have declined by 77%, 57%, and 77%, 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.

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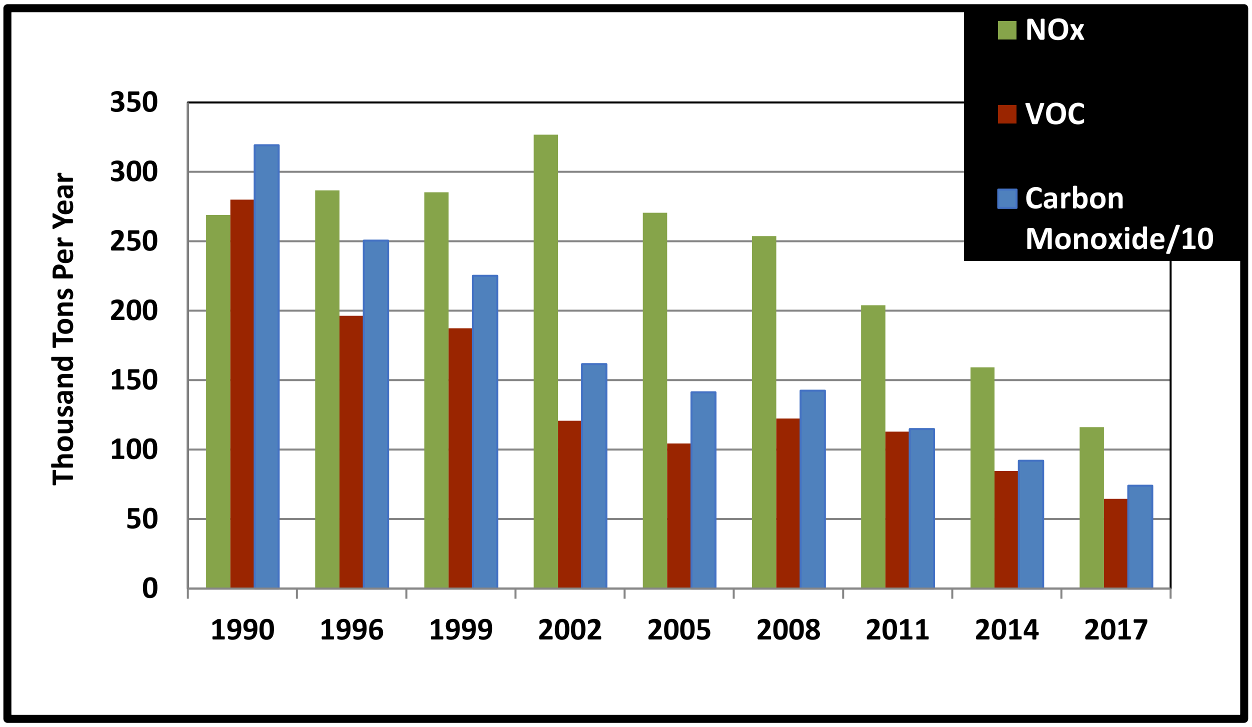
[1] U.S. Energy Information Administration, "Electricity Data Browser," available from https://www.eia.gov/electricity/data/browser/, accessed August 2020.

[2] U.S. Energy Information Administration, "Electric Power Annual, Table 4.7.B. Net Summer Capacity Using Primarily Renewable Energy Sources and by State, " accessed from https://www.eia.gov/electricity/annual/html/epa_04_07_b.html, accessed August 2020.

Onroad Mobile Source Emissions Reductions*

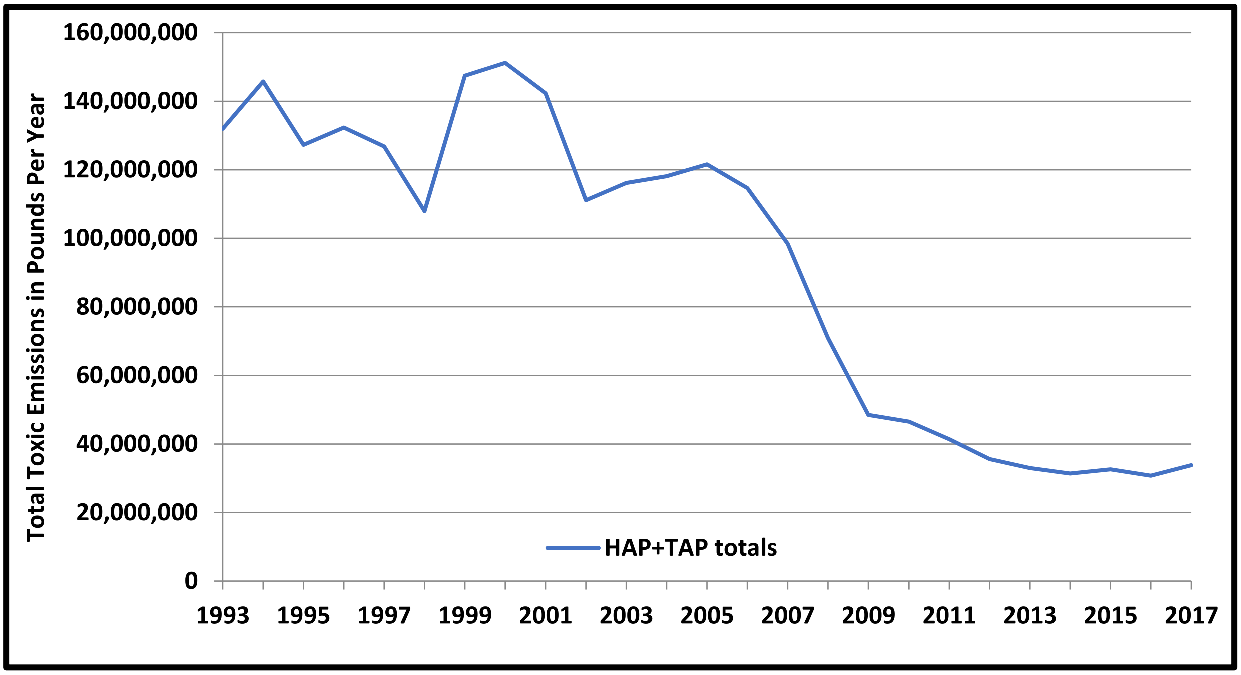


** The NOx emissions spike in 2002 is attributed to EPA adjusting the onroad emissions model.*
*** CO emissions represented in this chart were divided by a factor of 10 for comparability purposes.*

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 has been eliminated or reduced. As a result, HAP and TAP emissions have declined significantly over the past 25 years (see the following “Statewide Air Toxic Emissions Changes 1993-2017” chart). It is important to note that the number of HAPs and TAPs for which emissions are reported to the DAQ vary from year-to-year due to economic fluctuation in demand for products, process changes or improvements, and permitted facility population. For example, emissions were reported to the DAQ for 230 pollutants in 2014 and 236 pollutants in 2017. Additionally, the state is working alongside the Secretaries’ Science Advisory Board (SAB), U.S. Environmental Protection Agency (EPA), and academic researchers to find solutions for the scientific questions 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 1993-2017



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

Ambient Air Improvements

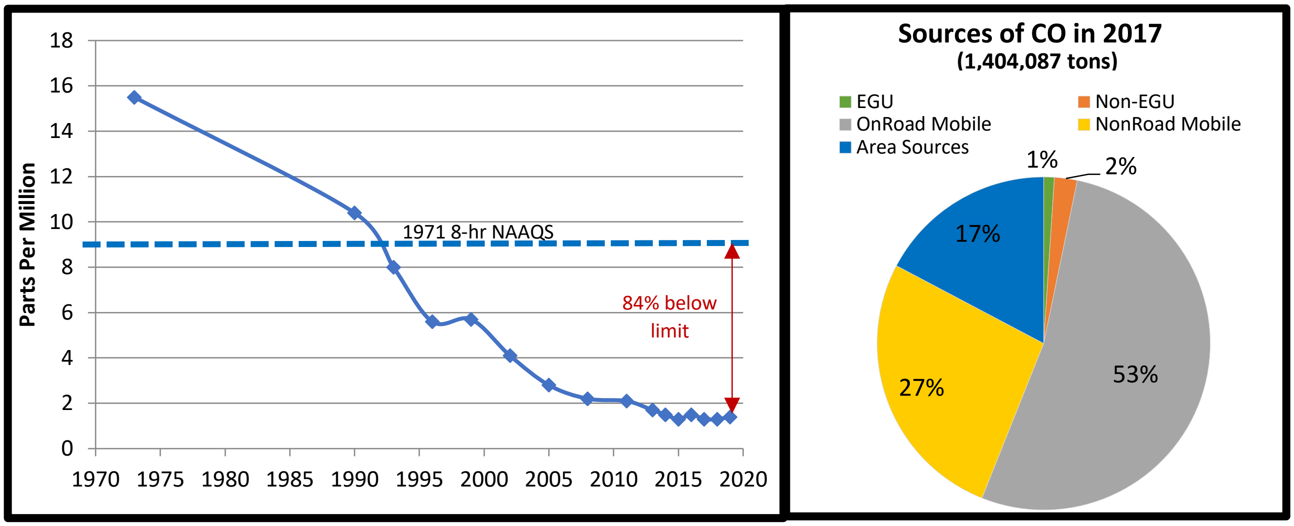
Air quality and visibility substantially improved across North Carolina. In the past, extensive portions of North Carolina had tropospheric ozone levels exceeding the health-based standard. The areas previously designated by EPA as not meeting air quality standards included more than 30 counties in the 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 2017-year emissions for CO, lead (Pb), SO_2, nitrogen dioxide (NO_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 buses are about 99% cleaner for common pollutants (such as CO, NOx, PM, and VOCs) compared to 1970 vehicle models.[3] North Carolina no longer has any CO maintenance areas, and all areas of the state are attaining the 1971 8-hour NAAQS.

[3] U.S. EPA, "History of Reducing Air Pollution from Transportation in the United States," https://www.epa.gov/transportation-air-pollution-and-climate-change/accomplishments-and-success-air-pollution-transportation, accessed August 2020.

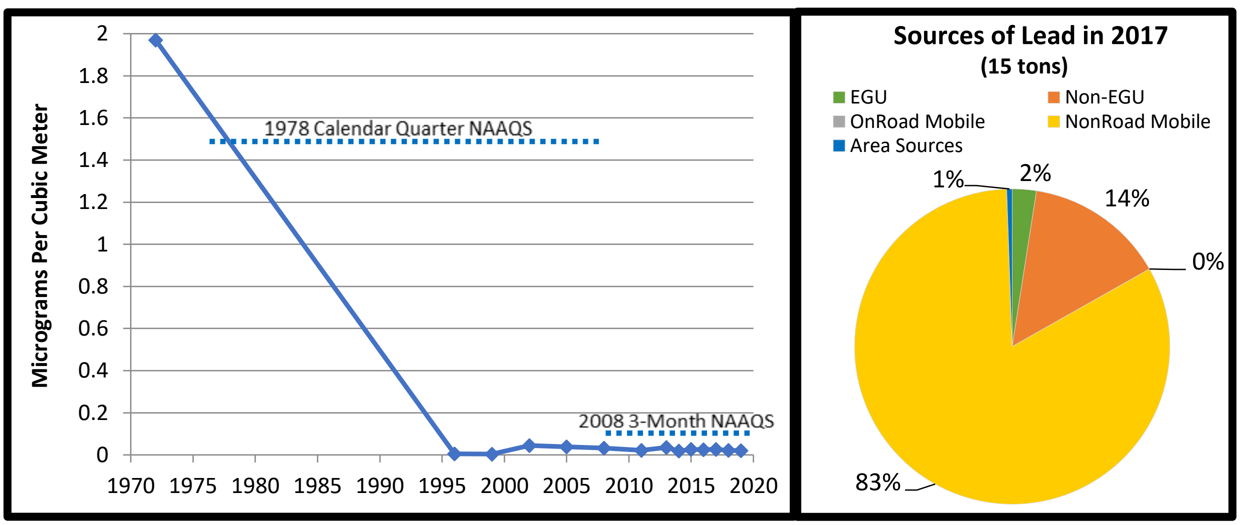
Statewide 8-hour Carbon Monoxide Levels



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. The measured lead design value was zero so the EPA no longer required North Carolina to monitor for lead to demonstrate compliance with the standard. However, as part of the chemical speciation network, North Carolina monitors for lead in fine particles at several locations throughout the state. The maximum measured fine particle lead value for each year is shown in the following chart.

Statewide Lead Concentrations

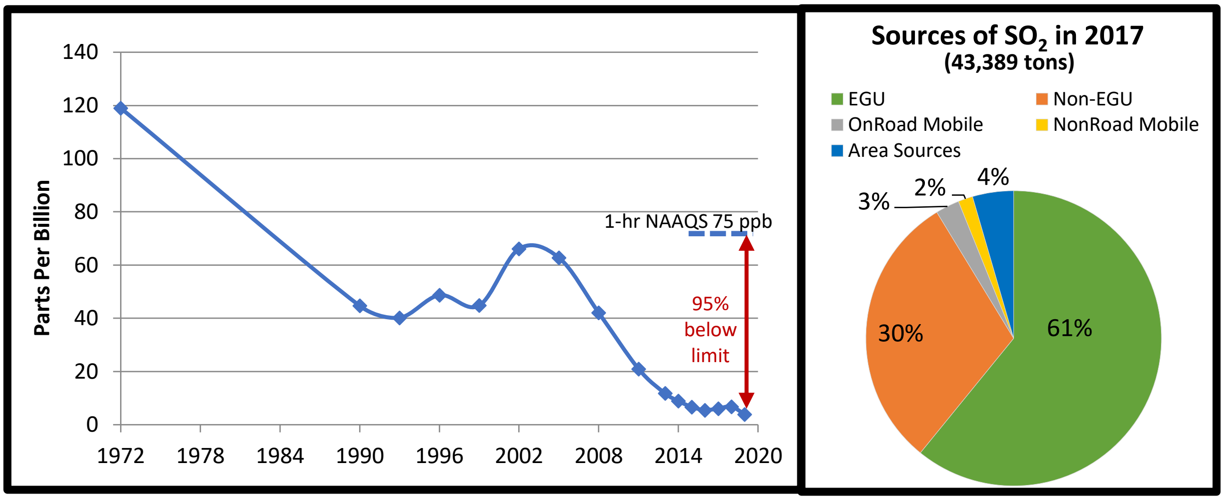


Notes: In the previous 2018 report, lead emissions from aircraft were reported in the non-EGU point and area sectors; the lead contribution from onroad mobile sources was negligible in 2017.

Sulfur Dioxide

Lower sulfur content in fuel,[4] 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. 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.[5] Brunswick County was designated "Unclassifiable" on June 30, 2016, as part of EPA's Round 2 action.[6] For calendar years 2017 through 2019, North Carolina completed source-oriented monitoring for three facilities (one each in Limestone Township in Buncombe County, Cunningham Township in Person County, and Beaverdam Township in Haywood County). The EPA will use the monitoring results along with emissions and other data to complete its final Round 4 designations by December 31, 2020, for each of the three remaining Townships.

Statewide SO_2 Concentrations

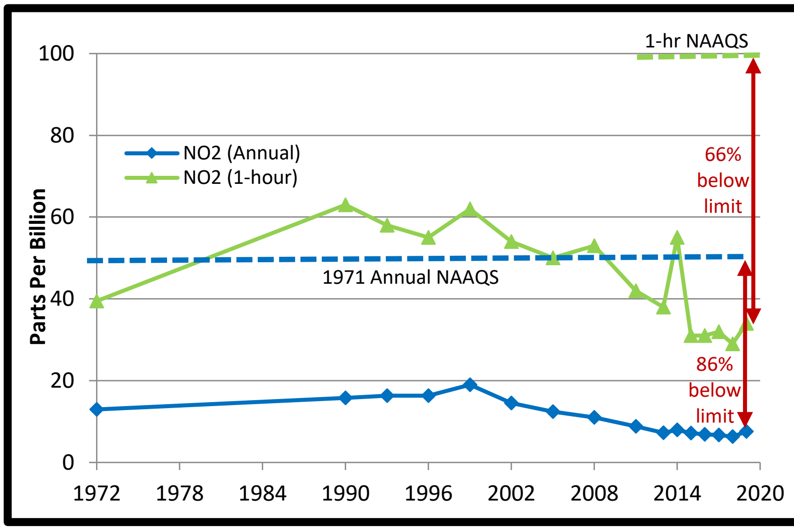


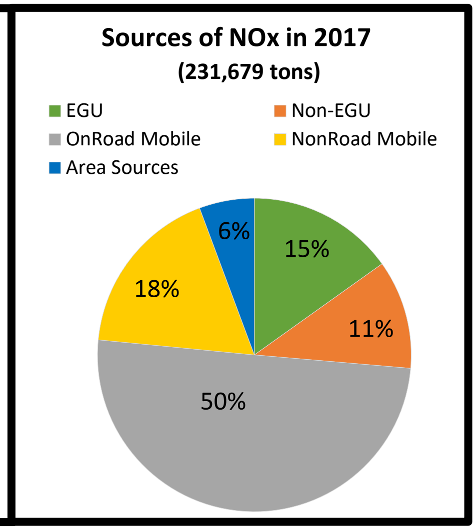
Nitrogen Dioxide

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" following chart). North Carolina is currently attaining both the 2010 1-hour and 1971 annual NO_2 NAAQS. Currently, there are 13 coal-fired EGUs across the state that are equipped with SCR controls, while 8 EGUs are equipped with SNCR.

[4] Since the 1960s, the sulfur content of gasoline and diesel fuel has dropped by 90% and 99%, respectively.
[5] 83 FR 1098, January 9, 2018. Designations were completed at the township-level.
[6] 81 FR 45039, July 12, 2016. Designations were completed at the township-level.

Statewide NO_2 Concentrations

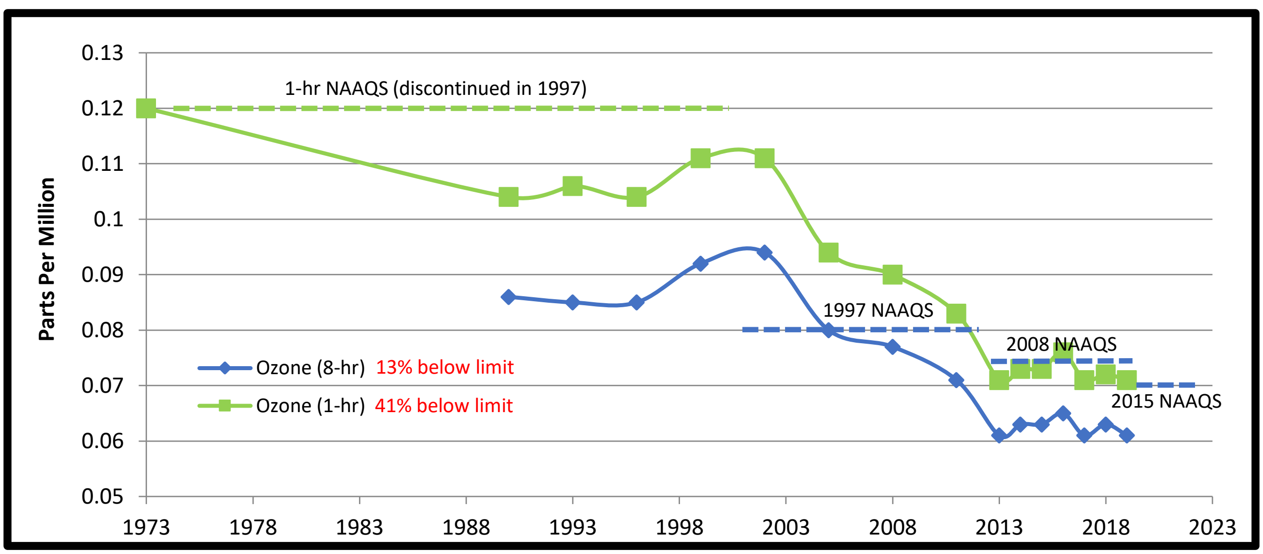




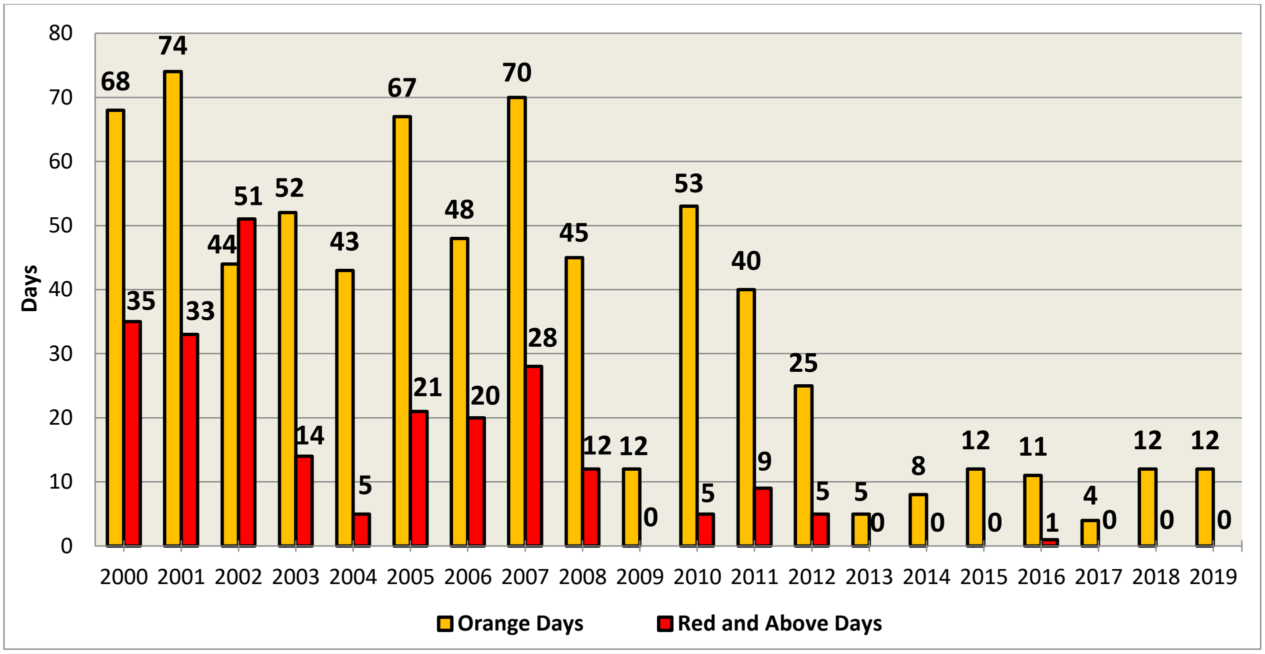
Ozone

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 exceedance days in North Carolina has remained low and has only varied slightly since the more stringent standard was adopted by EPA in 2015 (see the "Statewide Ozone Exceedances (2015 Standard) chart). Exceedance events have become increasingly localized -- limited predominantly to the Charlotte Metropolitan Area -- rather than being widespread across multiple metropolitan areas and surrounding regions of the state as was historically the case. The DAQ continues to evaluate each event to determine how best to minimize or eliminate exceedances in the future.

Statewide Average Ozone Concentrations



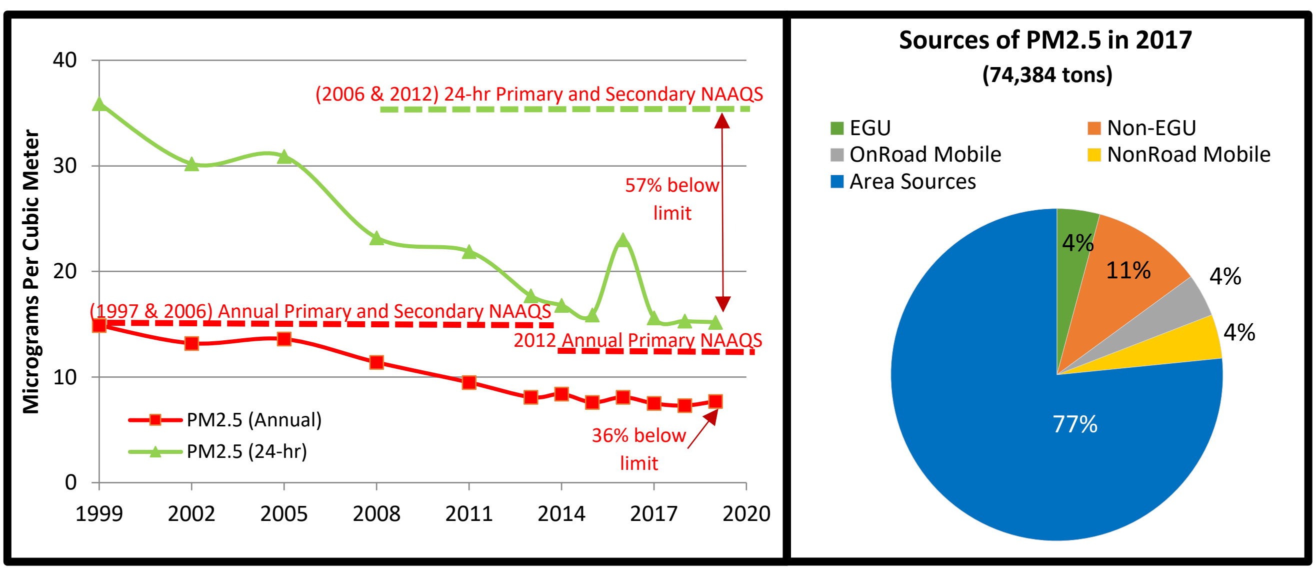
Statewide Ozone Exceedances (2015 Standard)



Particle Pollution

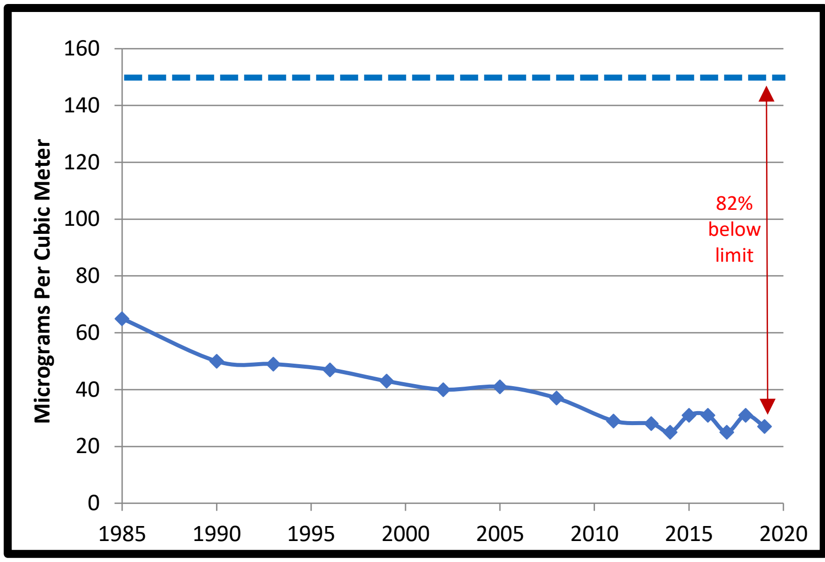
Reductions of NOx and SO_2 emissions from fossil fuel-fired EGUs, low-sulfur fuel standards, and mobile source PM have significantly lowered ambient $PM_{2.5}$ and PM_{10} concentrations across North Carolina.

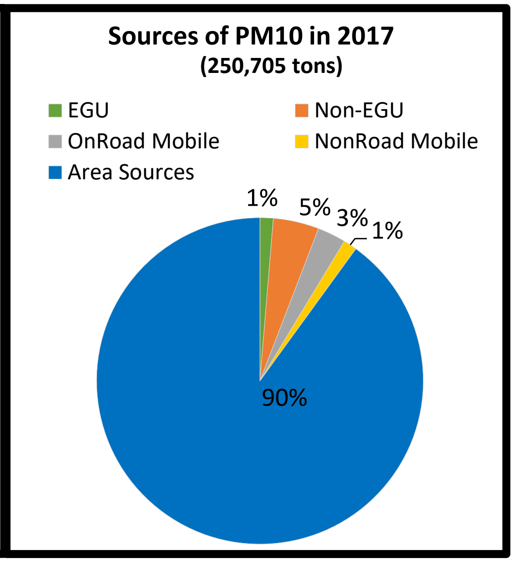
Statewide $PM_{2.5}$ Concentrations



Note: To provide the most accurate method for comparing monitored values to the $PM_{2.5}$ standard, the above $PM_{2.5}$ concentration values reflect only data from regulatory monitors.

Statewide PM_{10} Concentrations





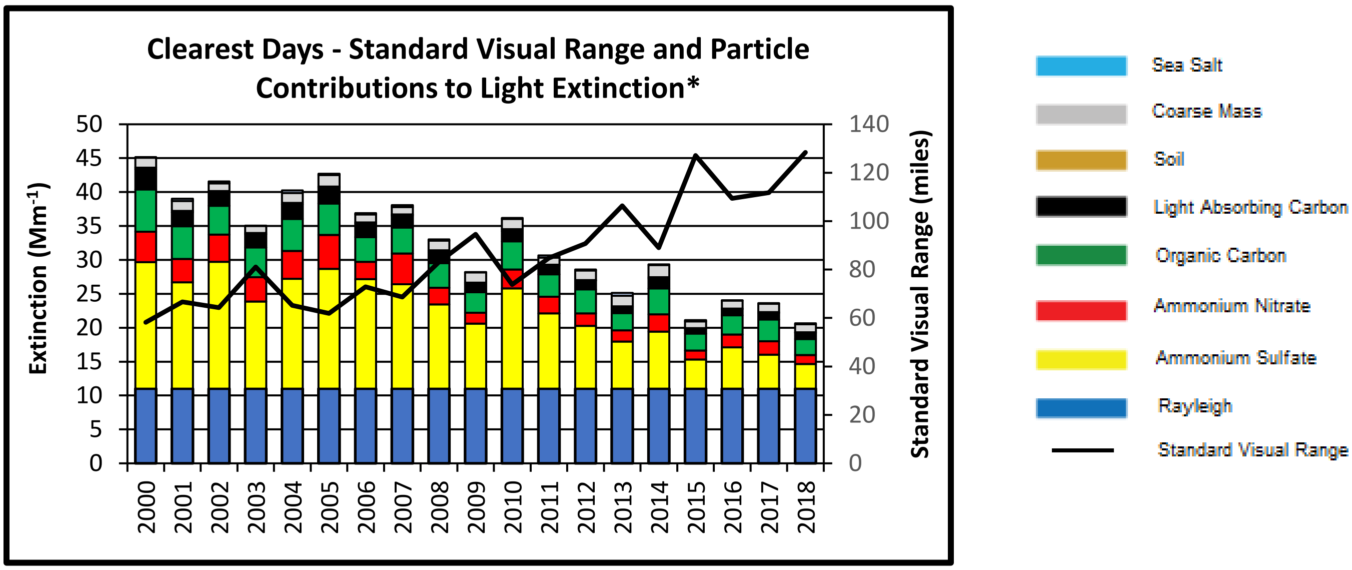
Visibility

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 has resulted in better visibility for North Carolina’s parks. For example, the following photos from Purchase Knob in the Great Smoky Mountains National Park show an increased visual range from 11.3 to 41.4 miles for days representing the median of the 20% most impaired days of 2005 and 2018, respectively.

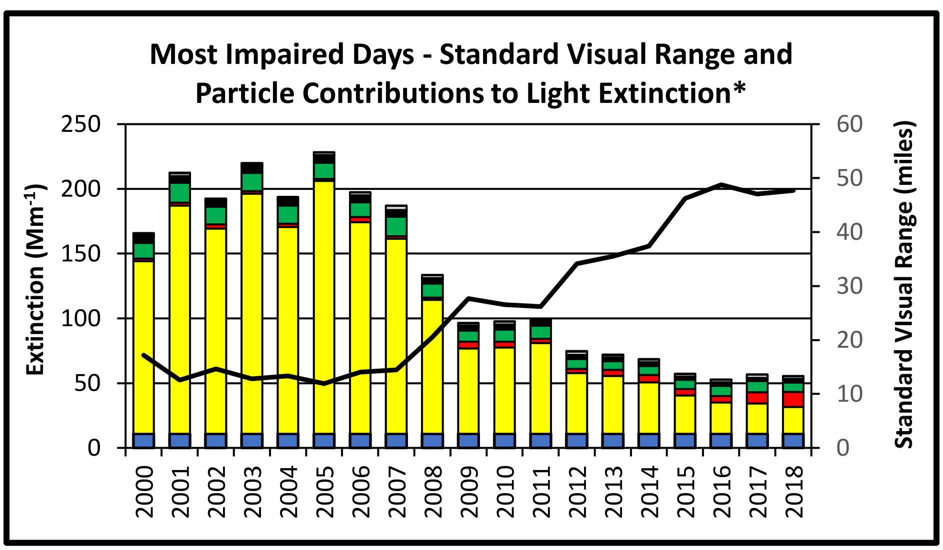
Archived View from Purchase Knob, Great Smoky Mountains National Park
September 1, 2005, 2:00 PM EST

Archived View from Purchase Knob, Great Smoky Mountains National Park
August 12, 2018, 3:00 PM EST

For the Great Smoky Mountains National Park, the following charts show the decline in pollutant species contribution to visibility impairment resulting in a corresponding increase in visual range for the 20% clearest and 20% most impaired days from 2000 through 2018. Note that Rayleigh represents natural light-scattering conditions. For the Great Smoky Mountains National Park, as with North Carolina's other Class I areas, anthropogenic visibility impairment has primarily been associated with SO_2 emissions that react with ammonia to form ammonium sulfate.



* 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. Standard visual range (SVR) represents the greatest distance at which an observer can just see a black object viewed against the horizon sky. SVR is derived from the total light extinction value.



* Light extinction is expressed as inverse megameters (Mm^{-1}). Light extinction values for each year represent the annual average of the 20% most impaired days as recorded by the IMPROVE monitor for the Great Smoky Mountains National Park. Standard visual range (SVR) represents the greatest distance at which an observer can just see a black object viewed against the horizon sky. SVR is derived from the total light extinction value.

The standard visual mile range on the 20% clearest days
1996: 54 miles
2000: 58 miles
2018: 128 miles

The standard visual mile range on the 20% most impaired days
1996: 11 miles
2000: 17 miles
2018: 48 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 150 million metric tons of carbon dioxide equivalent emissions (MMT CO_2e).[7,8] Accounting for carbon sinks, North Carolina's net GHG emissions in 2017 are estimated at about 116 MMT CO_2e. From 2005 to 2017, North Carolina reduced its gross and net GHG emissions by 19% and 24%, 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	40.21	55.19	46.36	49.02	48.72
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**	**136.89**	**184.74**	**158.18**	**154.82**	**150.08**
Percent Reduction in Gross Emissions from 2005					**19%**
Net Carbon Sinks - Land Use, Land Use Changes and Forestry	-35.64	-32.66	-33.97	-34.16	-34.03
Net Emissions**	**101.25**	**152.08**	**124.22**	**120.66**	**116.06**
Percent Reduction in Net Emissions from 2005					**24%**

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.

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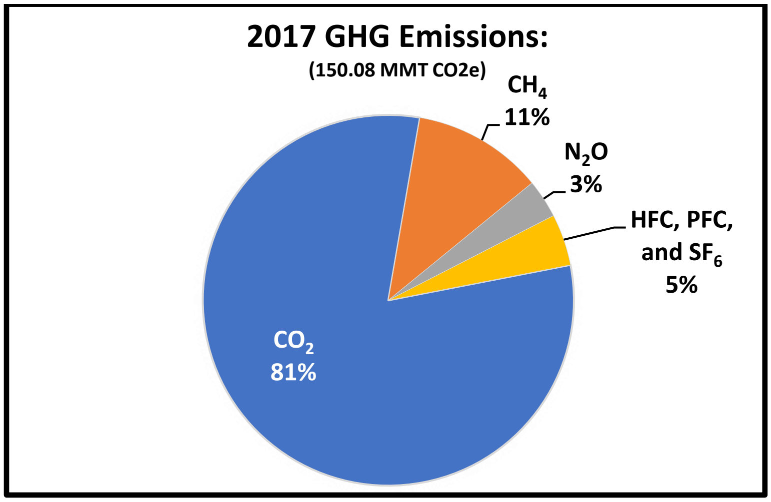
[7] North Carolina Greenhouse Gas Inventory (1990 – 2030), North Carolina Department of Environmental Quality, Division of Air Quality, January 2019. 2015 is the last year of historic GHG emissions data. 2017 is a short-term projection of GHG emissions and is treated as historical data for this analysis. For the largest-emitting sectors, North Carolina has plans to update the emissions estimates to reflect the latest historical data, and currently anticipates the release of this update in early 2021.

[8] 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.

The following lists 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 35% 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 8% 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 32% of all GHG emissions.
  - Emissions from the transportation sector have decreased by 12% from 2005 to 2017.

- Gasoline represents 72% of the energy input into transportation while diesel represents 20%.

- **Residential, Commercial, and Industrial**
  - Residential, commercial, and industrial fuel combustion emissions represent over 14% 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 44% 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.
- **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.