1.0 Executive Summary

This report presents North Carolina's greenhouse gas (GHG) inventory, a detailed accounting of GHGs emitted or stored by key source categories from 1990 to 2017. In addition, the inventory projects North Carolina's GHG emissions from 2018 to 2030 based on forecasted changes in fuel use, land use, population, historical trends, and other factors. GHGs are air pollutants as defined by a United States Supreme Court decision and subject to regulation by the U.S. Environmental Protection Agency (EPA) under the Clean Air Act.[1] In the report body, only select years are presented; however, estimated GHG emissions data for all analysis years, from 1990 to 2030, are summarized in Appendix A.

The methods used to prepare the North Carolina inventory are based on those used to prepare the Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2016 (U.S. Inventory), annually published by EPA.[2] The U.S. Inventory includes estimates of historic anthropogenic emissions of GHG sources and carbon sinks by source category, economic sector, and GHG pollutant type starting from 1990 for the entire country.[3] It is calculated using methodologies consistent with those recommended in the 2006 Intergovernmental Panel on Climate Change Guidelines for National Greenhouse Gas Inventories (IPCC Guidelines).[4] The use of consistent methodologies ensures that GHG inventories prepared by states and other entities are comparable.

1.1 Greenhouse Gases Included in the Inventory

The North Carolina historic and projected emissions inventory presented here estimates emissions of the six primary GHG pollutants listed below.[5]

[1] *Massachusetts et al. v. Environmental Protection Agency et al*., U.S. Supreme Court, 549 U.S. 497, April 2, 2007, https://www.supremecourt.gov/opinions/06pdf/05-1120.pdf.

[2] Draft Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2016, EPA 430-P-18-001, U.S. Environmental Protection Agency, Washington, D.C., February 6, 2018.

[3] Carbon sinks are natural or artificial reservoirs that accumulate and store a carbon-containing chemical compound (generally CO_2) for an extended period, such as the growth of newly planted trees in a sustainably managed forest.

[4] 2006 IPCC Guidelines for National Greenhouse Gas Inventories, The National Greenhouse Gas Inventories Programme, The Intergovernmental Panel on Climate Change. Hayama, Kanagawa, Japan, 2006, https://www.ipcc-nggip.iges.or.jp/public/2006gl/.

[5] These six compounds are being reported under the U.S. GHG reporting program. For information on each compound, see https://www.epa.gov/ghgemissions/overview-greenhouse-gases.

carbon dioxide (CO_2)	hydrofluorocarbons (HFCs)
methane (CH_4)	perfluorocarbons (PFCs)
nitrous oxide (N_2O)	sulfur hexafluoride (SF_6)

Emissions of each GHG are reported using the common metric "CO_2 equivalent emissions (CO_2e)." This approach normalizes the emissions of the various GHGs to reflect the global warming potential (GWP) of each compound with CO_2 as a baseline.[6] Using a common metric allows the quantity of each GHG compound emitted to be compared on the same basis. It also allows emissions of each GHG compound to be summed together to show the total impact of GHGs. For instance, it allows CH_4 emitted from landfills to be compared to the aggregate of CO_2, CH_4 and N_2O emitted from power plants. Appendix B contains a discussion of GWPs.

1.2 Emission Sources Included in the Inventory

North Carolina's GHG emissions inventory covers all GHG sources and carbon sink categories that are included in the national inventory prepared by EPA and are representative of activities occurring in our State. This includes emissions from Combustion Processes, Industrial Processes, and Waste Management activities.[7] It also includes fugitive emissions from Natural Gas Transmission and Distribution systems, Agriculture Operations, and from Land Use activities such as fertilization and forest fires. Lastly, the emissions inventory includes estimates of the indirect emissions associated with Imported Electricity consumed in North Carolina but generated outside the State. North Carolina's GHG inventory does not include coal, oil, and gas production, cement manufacture, lime manufacture, ammonia production, nitric acid production, adipic acid production, magnesium production, and the production of the refrigerant chlorodifluoromethane (HCFC-22) because these activities do not occur in the State. With additional refinements in emissions estimation methods, it may be possible for future inventories to include a broader scope of indirect emissions beyond Electricity consumption.[8]

The Land Use, Land Use Changes and Forestry (LULUCF) sector is the net sum of all CH_4 and N_2O emissions to the atmosphere from activities on natural and working lands plus the net change in the carbon stocks for each year. Changes in the growth, decay, storage, and use of the carbon-based stocks on North Carolina's natural and working lands, often referred to as carbon flux, are estimated for both the historic and projected emissions inventory in the LULUCF

[6] For more information on global warming potential, see https://www.epa.gov/climateleadership/atmospheric-lifetime-and-global-warming-potential-defined.

[7] Combustion processes include burning of coal, natural gas, fuel oil, biomass, and other fuels for electricity generation, process heat, space and water heating, and onroad and non-road transportation, and other combustion processes in the State.

[8] Indirect emissions are generated in other states from activities associated with goods consumed in North Carolina (see further discussion in Appendix D).

sector.[9] For all years, North Carolina's forestry management practices result in a net sequestration of carbon and are reported as a carbon sink. (See Section 2.9.)

CO_2 emissions from the combustion of biomass must be treated differently than fossil fuel sources in the inventory. This is because the release of carbon from biomass combustion is accounted for in the LULUCF sector per the IPCC Inventory Guidelines. Therefore, including biomass combustion CO_2 emissions elsewhere (i.e., within each applicable combustion sector) would result in double-counting emissions. For these reasons, biomass combustion emissions are included within the net emissions reported for the LULUCF sector. For transparency, and in keeping with EPA's national GHG inventory reporting, North Carolina's inventory presents gross CO_2 emissions from biomass combustion in North Carolina in Appendix C, which provides additional discussion on the treatment of CO_2 emissions from biomass combustion. Note that CH_4 and N_2O gross emissions from biomass combustion are included in the inventory within the relevant consumption sector (e.g., Residential/Commercial/Industrial combustion) since these emissions are not accounted for in the LULUCF sector.

1.3 GHG Emissions Estimation Methods

Both the historic and projected GHG emissions are calculated primarily using the "State Inventory and Projection Tool (SIT)," a spreadsheet-based tool developed by EPA to assist state agencies in preparing state-level GHG inventories and projections.[10] The SIT automates the estimation procedures used by EPA to prepare the national GHG inventory for use in preparing state-level GHG inventories.

The SIT includes default data supplied by EPA for North Carolina and other states. The default data are generally publicly available information from various federal agencies such as the U.S. Department of Energy (DOE), U.S. Department of Agriculture (USDA), Federal Highway Administration (FHWA), U.S. Geological Survey (USGS), U.S. Census Bureau, and EPA. These data are frequently used by state and local agencies to develop air pollutant emissions inventories. A limited number of source categories contained in the SIT (e.g., fertilizer application) utilize data obtained from third party vendors. Where default data were unavailable or considered inferior relative to other information sources, data obtained from state agencies are used in the SIT to provide more accurate emissions estimates for North Carolina. Examples of state-specific refinements include: (1) replacing the default CH_4 emission factor for natural gas compressor stations to reflect the average emissions of North Carolina compressor stations that report to EPA's GHG Reporting Program; (2) adding North Carolina poultry production data obtained from the NC Department of Agriculture and Consumer Services where no default data are included in the SIT Wastewater Module; and (3) using waste in place data from the North

[9] Natural and working lands include public and private forests, cropland, grassland, wetlands and "settlement" lands, where settlement refers to both urban and rural communities.

[10] State Inventory and Projection Tool, US Environmental Protection Agency, https://www.epa.gov/statelocalenergy/download-state-inventory-and-projection-tool accessed January 3, 2018.

Carolina Division of Waste Management. The data sources used to estimate emissions are documented in Section 3.0 of this report.

A discussion of the uncertainty associated with the default data available in the SIT is located in each SIT module under the tab labeled "Uncertainty."[11] A discussion of the uncertainty associated with the data and methodology used outside of the SIT is available upon request.

1.4 Reference Case Projection

The projection of the GHG inventory includes all sectors that were estimated for the historic inventory. The projection represents a single reference case for future GHG emissions. No future year scenarios are included in the projections since potential scenarios have not been quantified at this time. This reference case projection will be used to evaluate the impact of future scenarios with policies, programs, or rules that increase or decrease emissions.

There is uncertainty in this reference case projection due to EPA's potential replacement of several regulations involving GHG emissions including; 1) fossil fuel power plant CO_2 emissions, 2) landfill CH_4 emissions 3) corporate average fuel economy (CAFE) standards for vehicles, and 4) phasedown of HFCs under the Montreal Protocol.[11,12] The reference projection still includes the emissions reductions from these regulations, except for Electricity Generation. The Electricity Generation projection does not include any regulation of CO_2 emissions in the future since this regulation has already been removed from the forecast for this sector. Future inventories will incorporate any final regulatory changes.

As stated above, future decreases in GHGs through various mitigations strategies that may be employed by North Carolina are not included. Mitigation strategies along with their impact to net GHG emissions will be evaluated separately to estimate GHG reduction potential in a future year. Examples of mitigation strategies that may be evaluated include; 1) increase in the use of renewable energy, energy efficiency, and storage, 2) increase in the use of electric vehicles, 3) livestock manure management, and 4) sequestration of carbon by natural and working lands.

1.5 GHG Inventory Results

Table 1-1 summarizes the estimates of North Carolina's historical and projected GHG emissions and carbon sinks from 1990 through 2030.[13] Some important details about the table are listed below.

[11] The Montreal Protocol's charter is to save the upper atmosphere ozone layer that protects from the sun's ultraviolet rays that cause skin cancer (see U.S. Department of State, "The Montreal Protocol on Substances That Deplete the Ozone Layer," https://www.state.gov/e/oes/eqt/chemicalpollution/83007.htm, accessed May 2018.)
[12] https://www.epa.gov/laws-regulations/epa-deregulatory-actions
[13] The data for all years are presented in Appendix A.

- Emissions are presented in million metric tons as CO_2 equivalent emissions (MMT CO_2e).
- In keeping with IPCC guidelines, CO_2 emissions from combustion of biomass are included within the calculation of net carbon flux in the LULUCF sector (see Appendix C for further discussion of the treatment of biomass CO_2 emissions).
- 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.
- Emissions reductions are presented for a base year of 2005 as well as 2025, which corresponds with the baseline and projection years specified by the Paris Agreement, an agreement within the United Nations Framework Convention on Climate Change (UNFCCC) dealing with GHG-emissions mitigation, adaptation, and finance.[14]

Based on the estimated emissions in Table 1-1, North Carolina's gross GHG emissions in 2017 are 150 MMT CO_2e.[15] Accounting for carbon sinks, North Carolina's net GHG emissions in 2017 are estimated at 116 MMT CO_2e and are projected to decrease to 104 MMT CO_2e by 2025. Using a base year of 2005, North Carolina reduced its net GHG emissions by 24% between 2005 and 2017. North Carolina's projected net post-2005 GHG reductions in 2025 are 31%, which is greater than the U.S. commitment to reduce GHG emissions by 26% to 28% by 2025 under the Paris Agreement.[16]

[14] https://treaties.un.org/pages/ViewDetails.aspx?src=TREATY&mtdsg_no=XXVII-7-d&chapter=27&clang=_en
[15] 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.
[16] Cover Note INDC and Accompanying Information, UNFCCC http://www4.unfccc.int/submissions/INDC/

Table 1-1: North Carolina GHG Emissions Inventory by Source Sector (MMT CO_2e)

	Historic					Projected		
	1990	**2005**	**2012**	**2015**	**2017**	**2020**	**2025**	**2030**
Electricity Use	**54.57**	**79.37**	**66.85**	**58.48**	**52.60**	**45.74**	**40.59**	**42.46**
Electric Power Generation	46.28	73.27	55.95	51.10	45.32	38.34	32.99	34.70
Imported Electricity[a]	8.29	6.10	10.90	7.37	7.28	7.39	7.60	7.76
Residential/Commercial/Industrial Combustion[b]	**26.77**	**26.02**	**18.66**	**21.15**	**20.92**	**22.52**	**23.26**	**23.92**
Industrial	17.59	14.21	10.00	9.97	9.93	11.32	12.16	12.62
Commercial	3.79	5.06	4.17	5.76	5.72	5.84	5.76	5.93
Residential	5.39	6.75	4.48	5.43	5.28	5.36	5.35	5.38
Transportation	**40.21**	**55.19**	**46.36**	**49.02**	**48.72**	**45.27**	**41.00**	**39.22**
Gasoline & Diesel Highway	35.13	48.21	41.60	44.00	44.05	40.47	36.02	34.02
Non-Highway	5.08	6.96	4.72	4.98	4.62	4.74	4.91	5.12
Alternative Fuel Vehicles	0.00	0.03	0.04	0.05	0.05	0.06	0.07	0.08
Agriculture	**7.06**	**10.65**	**10.56**	**10.38**	**10.53**	**10.51**	**10.47**	**10.44**
Manure Management	2.59	6.02	5.63	5.90	6.05	6.06	6.09	6.11
Agricultural Soil Management	2.87	2.74	3.18	2.74	2.84	2.82	2.78	2.75
Enteric Fermentation	1.60	1.89	1.74	1.73	1.64	1.63	1.60	1.58
Burning of Agricultural Crop Waste	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Waste Management	**6.39**	**8.52**	**9.09**	**8.44**	**8.77**	**9.29**	**10.17**	**11.07**
Municipal Solid Waste	5.47	7.23	7.52	6.82	7.09	7.52	8.26	9.00
Wastewater	0.92	1.29	1.57	1.61	1.68	1.77	1.92	2.06
Industrial Processes	**1.04**	**3.83**	**5.39**	**6.03**	**7.18**	**8.84**	**11.31**	**12.73**
Natural Gas and Oil Systems	**0.86**	**1.17**	**1.28**	**1.32**	**1.35**	**1.40**	**1.47**	**1.55**
Gross Emissions	**136.89**	**184.74**	**158.18**	**154.82**	**150.08**	**143.57**	**138.28**	**141.37**
Net Carbon Sinks – LULUCF[c]	**-35.64**	**-32.66**	**-33.97**	**-34.16**	**-34.03**	**-34.03**	**-34.03**	**-34.03**
Net Emissions	**101.25**	**152.08**	**124.22**	**120.66**	**116.06**	**109.55**	**104.25**	**107.35**
Percent Reduction in Net Emissions from 2005					**24%**		**31%**	

Note: Totals may not equal exact sum of subtotals shown in this table due to independent rounding.
[a] Includes estimates of emissions from Imported Electricity that are generated outside North Carolina.
[b] Represents emissions associated with on-site fuel combustion activities in the Residential, Commercial, and Industrial sectors.
[c] Land Use, Land Use Changes and Forestry.

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. Additional detail is provided in Section 2.0 Trends in Greenhouse Gas Emissions. Emissions reductions are generally expressed as the percent change in gross GHG emissions, unless otherwise stated, from the baseline year of 2005 to 2017.

- **North Carolina's Gross and Net Emissions**
  - North Carolina reduced gross GHG emissions by 19% and net GHG emissions by 24% since 2005.
  - During this same time period, North Carolina's population and real Gross State Product (GSP) grew by 18%.

- By 2025, net GHG emissions are projected to decrease by 31% from the 2005 baseline, indicating North Carolina is forecast to achieve the U.S 2025 reduction target of 26% to 28%.

➢ **GHG Compounds**

- Carbon dioxide emissions currently account for approximately 82% of total GHG emissions.
- The primary source of CO_2 emissions is fossil fuel combustion.
- GHG emissions from fossil fuel combustion have decreased by 26% since 2005. This is due to both a shift in fuel use, from coal to natural gas, and increased energy efficiency.
- Methane (CH_4) emissions currently account for approximately 11% of total GHG emissions
- 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.

➢ **Electricity Sector**

- 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 (MW) of coal fired power plants, which is 25% of the NC coal fleet.
  2) increased use of efficient natural gas combined cycle plants
  3) North Carolina legislation to promote renewable energy
- Solar, 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 about 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 21%.
- Projections for gas and diesel vehicle emissions under the current CAFE and GHG standards suggest a substantial decrease in GHG emissions. However, EPA has proposed to relax the last phase of these standards, suggesting projected emission reductions may be lower than forecast here.

➢ **Residential Commercial and Industrial**

- Residential, Commercial and Industrial emissions represent 19% 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 used by this sector.

- Industrial fuel combustion emissions have decreased by 30% since 2005.
- GHG emissions from Industrial Processes have doubled since 2005.

➢ **Land use, Land Use Changes and Forestry**

- Forests, natural lands, and agricultural lands sequestered an estimated 34 MMT of CO_2 or 25% of gross GHG emissions estimated in 2017.
- 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.

➢ **Landfills**

- Many large landfills in North Carolina are now collecting CH_4 and using the captured biogas as energy, resulting in 561,000 MWh of Electricity Generation and an additional 149,000 million British thermal units (MMBtu) of heat input in 2017.
- There has been a reduction in GHG emissions from this sector since 2005, despite a large growth in population. This is primarily due to the energy recovery from landfill gas.

1.6 Structure of the Report

The remainder of this report is divided into two sections. The first section is an analysis of the key economic sectors and a discussion of the trends in North Carolina's GHG sources and sinks. The second section discusses the methodologies and data sets used to prepare the estimates, including key assumptions and limitations. Appendix A provides a tabulated summary of each year of GHG emissions from 1990 to 2030. Appendix B provides a brief overview of global warming potentials and Appendix C discusses the treatment of CO_2 emissions from biomass combustion. Appendix D summarizes comments received on the draft Inventory report during the public comment period, which was open between November 2nd and December 14th of 2018. This Appendix also provides responses to these comments and a description of the appropriate method used to modify the inventory.