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North Carolina **Greenhouse Gas** Inventory (1990-2030)

January 2022

North Carolina **Greenhouse Gas** Inventory

(1990 – 2030)

North Carolina Department of Environmental Quality

Division of Air Quality

January 2022

Purpose

This emissions inventory provides a high-level perspective of anthropogenic greenhouse gas (GHG) emissions from various economic sectors in North Carolina. It represents North Carolina's "carbon footprint." The inventory can be used by environmental planners and energy policy makers in our State to understand past, current, and expected future GHG emissions in North Carolina. It can also be used as a baseline to evaluate and develop GHG mitigation options for our State and predict their effect on reducing emissions in future years. This report does not discuss the impact of GHGs on climate.

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. The GHG inventory utilizes data sets assembled by the EPA, federal agencies, and state agencies. This report is a biennial update to the 2019 GHG inventory. The GHG inventory is updated to incorporate advancements in data and methodologies, as appropriate. This update covers the 4 major sectors accounting for a large majority of GHG emissions/sinks: Electricity; Transportation; Residential, Commercial, and Industrial (RCI) Fuel Combustion; and Land Use, Land Use Change, and Forestry (LULUCF). Other sectors' emissions estimates have been carried forward from the 2019 GHG inventory.

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Acronyms

AEO	Annual Energy Outlook
BEV	battery electric vehicles
CAFE	Corporate Average Fuel Economy
C&D	construction and demolition
CH_4	methane
CO_2	carbon dioxide
CO_2e	carbon dioxide equivalent
COVID	Coronavirus
CSA	Clean Smokestacks Act
DAQ	North Carolina Division of Air Quality
DOE	U.S. Department of Energy
eGRID	Emissions & Generation Resource Integrated Database
EIA	U.S. Energy Information Administration
EO	Executive Order
EPA	U.S. Environmental Protection Agency
GHG	greenhouse gas
GSP	gross state product
GWP	global warming potential
FHWA	Federal Highway Administration
HCFC-22	chlorodifluoromethane
HFCs	hydrofluorocarbons
HWP	harvested wood products
IBEAM-ED	Internet-Based Enterprise Application Management - Emissions Data Module
IPCC	Intergovernmental Panel on Climate Change
kWh	kilowatt-hour
lb	pound
LFGTE	landfill-gas-to-energy
LMOP	Landfill Methane Outreach Project
LNG	liquified natural gas
LULUCF	Land Use, Land Use Change, and Forestry
MATS	Mercury and Air Toxics Standard
MMBtu	million British thermal units
MMT	million metric tons
MSW	Municipal Solid Waste
MW	megawatt
MWh	megawatt-hour
NASS	National Agricultural Statistics Service

NC	North Carolina
NC DOT	North Carolina Department of Transportation
NCUC	North Carolina Utilities Commission
NCFS	North Carolina Forest Service
NEI	National Emissions Inventory
NGCC	natural gas combined cycle
NIFC	National Interagency Fire Center
NHTSA	National Highway Traffic Safety Administration
N_2O	nitrous oxide
ODS	ozone-depleting substance
PFCs	perfluorocarbons
PHMSA	Pipeline and Hazardous Materials Safety Administration
RCI	Residential, Commercial, and Industrial
RE	renewable energy
REPS	Renewable Energy and Energy Efficiency Portfolio Standard
RFS	Renewable Fuel Standard
SEDS	State Energy Data System
SF_6	sulfur hexafluoride
SL	State Law
SRVC	Southeastern Electric Reliability Council - Virginia/Carolina Subregion
SIT	State Inventory and Projection Tool
U.S.	United States
USDA	U.S. Department of Agriculture
USFS	U.S. Forest Service
USGS	U.S. Geological Survey
VMT	vehicle miles traveled
ZEV	zero-emission vehicle

1.0 Executive Summary

1.1 Overview

This report presents North Carolina's greenhouse gas (GHG) inventory, a detailed accounting of historical activities and associated GHGs emitted or stored by key source categories from 1990 to 2018. In addition, the inventory projects North Carolina's GHG emissions from 2019 to 2030 based on forecasted changes in fuel use, population, historical trends, and other factors.

North Carolina uses the inventory to benchmark progress on GHG reductions against state goals and policies to determine which sectors offer opportunities for future reductions. According to the updated inventory, between 2005 and 2018, North Carolina reduced gross GHG emissions by 16% and net GHG emissions by 23%. By 2030, North Carolina is projected to see a 39% decrease in net GHG emissions as a result of current trends across all sectors and the reductions required in the electricity sector under Session Law (SL) 2021-165 (House Bill 951).

For this inventory and forecast, significant revisions were made to the transportation sector analysis due to newly available data and the use of an updated EPA-approved transportation model. The revised numbers in this inventory show that the transportation sector is responsible for approximately 17% more emissions in 2017 than in the previous inventory. This sector now accounts for 36% of the state's gross GHG emissions and is projected to decrease emissions at a much lower rate compared to the projected decrease in electricity generation emissions by 2030. However, the transportation projections do not include reductions expected as a result of policies enacted after 2020.

The inventory also recognizes North Carolina's tremendous potential to offset carbon emissions through its land and forest resources. Due to changes in guidance from the EPA on modeling Land Use, Land Use Change, and Forestry (LULUCF), the updated estimates show land use and forestry sequestered 26% of statewide gross GHG emissions in 2018, which represents more carbon sequestration than previously reported.

Overall, the projections in this inventory validate North Carolina's focus on reductions to GHG emissions from the electricity sector and highlight the opportunity for additional efforts in the transportation sector. The state is making progress on reducing emissions and is on track for continued reductions. The inventory will be updated as more data become available on a biennial schedule.

The methods used to prepare the North Carolina inventory are generally based on those used to prepare the "Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2018" (U.S.

Inventory), published annually by EPA.[1] The U.S. Inventory includes estimates of historical anthropogenic emissions of GHG sources and carbon sinks by source category, economic sector, and GHG pollutant type for the entire country starting from 1990.[2] 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).[3] The use of consistent methodologies ensures that GHG inventories prepared by states and other entities are comparable. 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 North Carolina historical and projected emissions inventory presented here estimates emissions of the six primary GHG pollutants listed below.[4] The pollutant specific estimates are reported as CO_2 equivalent emissions using currently used Global Warming Potential (GWP).

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

Table 1-1 summarizes the estimates of North Carolina's historical and projected GHG emissions and carbon sinks from 1990 through 2030.[5] Details about the table are listed below.

- Emissions are presented in million metric tons as CO_2e (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 (Appendix C provides a detailed 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.
- The significant reduction in onroad vehicle emissions in 2020 reflects the estimated reduction in vehicle miles traveled resulting from the pandemic in that year.
- Emissions reductions are presented for a base year of 2005 as well as 2025 and 2030, which corresponds with the baseline and projection years specified by various Federal, multi-state, and North Carolina-specific GHG mitigation policies.

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[1] EPA, "Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2018," EPA 430-R-20-002, Washington, D.C., April 13, 2020, https://www.epa.gov/ghgemissions/inventory-us-greenhouse-gas-emissions-and-sinks-1990-2018.

[2] 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.

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

[4] 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.

[5] The data for all years are presented in Appendix A.

- An estimate of the impact associated with the 2030 goal to reduce CO_2 emissions by 70% from 2005 levels as specified in State Law (SL) 2021-165 on statewide emissions for the electric power generation sector and total statewide gross and net emissions is provided in the last column of Table 1-1.

Table 1-1: North Carolina GHG Emissions Inventory by Source Sector (MMT CO2e)

	Historical					Projected			
	1990	2005	2012	2017	2018	2020	2025	2030	2030 with SL 2021-165
Electricity Generation and Use	54.55	80.15	65.61	51.29	52.32	46.83	41.08	34.35	
Electric Power Generation	46.28	73.27	55.95	46.64	47.56	42.48	36.80	30.12	23.91
Imported Electricity[a]	8.27	6.88	9.65	4.65	4.76	4.35	4.28	4.23	
Residential/Commercial/Industrial Combustion[b]	26.76	26.00	18.74	19.83	21.28	19.65	21.38	21.96	
Industrial	17.58	14.20	10.10	10.18	10.43	9.74	10.59	11.18	
Commercial	3.79	5.06	4.17	5.06	5.22	4.82	5.42	5.48	
Residential	5.39	6.75	4.47	4.60	5.64	5.09	5.37	5.30	
Transportation	40.40	59.36	56.91	57.18	57.31	49.71	52.42	49.09	
Gasoline & Diesel Highway	35.23	51.79	51.01	51.82	51.68	44.35	46.49	42.88	
Non-Highway	5.17	7.51	5.78	5.18	5.46	5.16	5.72	5.96	
Alternative Fuel Vehicles	0.00	0.05	0.12	0.17	0.18	0.20	0.22	0.25	
Agriculture	7.06	10.65	10.56	10.53	10.52	10.51	10.47	10.44	
Manure Management	2.59	6.02	5.63	6.05	6.06	6.06	6.09	6.11	
Agricultural Soil Management	2.87	2.74	3.18	2.84	2.83	2.82	2.78	2.75	
Enteric Fermentation	1.60	1.89	1.74	1.64	1.63	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	8.77	8.94	9.29	10.17	11.07	
Municipal Solid Waste	5.47	7.23	7.52	7.09	7.23	7.52	8.26	9.00	
Wastewater	0.92	1.29	1.57	1.68	1.71	1.77	1.92	2.06	
Industrial Processes	1.04	3.83	5.39	7.18	7.73	8.84	11.31	12.73	
Natural Gas and Oil Systems	0.86	1.17	1.28	1.35	1.37	1.40	1.47	1.55	
Gross Emissions	137.04	189.68	167.56	156.13	159.48	146.23	148.31	141.18	134.97
Net Carbon Sinks – LULUCF[c]	-42.17	-37.29	-40.15	-41.58	-42.13	-42.13	-42.13	-42.13	
Net Emissions	94.88	152.39	127.41	114.56	117.35	104.10	106.18	99.05	92.84
Percent Reduction in Net Emissions from 2005					**23%**		**30%**	**35%**	**39%**

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 Change, and Forestry.

1.2 Key Findings

Based on the estimated emissions in Table 1-1, North Carolina's gross GHG emissions in 2018 were 159 MMT CO_2e and are projected to decrease by 11% to 141 MMT CO_2e by 2030.[6] Accounting for

[6] 2018 is the last year of historical GHG emissions data; 2012 and 2017 are also displayed in Table 1-1 to demonstrate recent emission trends.

carbon sinks, North Carolina's net GHG emissions in 2018 are estimated at 117 MMT CO_2e and are projected to decrease by 16% to 99 MMT CO_2e by 2030. North Carolina's projected net post-2005 GHG reductions in 2025 and 2030 are 30% and 39%, respectively. The 2025 net GHG emission reduction projection does not consider SL 2021-165 in this report. There is not enough information to project year-over-year emissions decreases leading up to the 70% CO_2 reductions by 2030 requirement. More information will be established in the North Carolina Utilities Commission (NCUC) Carbon Plan.

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. Unless otherwise stated, emission reductions are generally expressed as the percent change in gross GHG emissions from the baseline year of 2005.

- **North Carolina's Gross and Net Emissions**
  - Between 2005 and 2018, North Carolina reduced gross GHG emissions by 16% and net GHG emissions by 23%.
  - During this same time period, North Carolina's population and real Gross State Product (GSP) grew by 19% and 24%, respectively.
  - By 2025, net GHG emissions are projected to decrease by 30% relative to 2005 baseline emissions.
  - By 2030, net GHG emissions are forecast to decrease by 39% relative to the 2005 baseline.
  - The 2025 and 2030 projections do not include all reductions expected as a result of policies enacted after 2020.
- **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 21% between 2005 and 2018. This is due to both a shift in fuel use, from coal to natural gas, and increased energy efficiency.
  - Methane emissions currently account for approximately 11% of total GHG emissions.
  - The primary sources of methane 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 Generation and Use Sector**
  - While previously the largest contributor to GHG emissions, Electricity Generation and Use is now the second largest emissions sector and represents 33% of all GHG emissions.
  - GHG emissions from the Electricity Generation and Use sector in 2018 decreased by 34% since 2005
  - North Carolina's electricity generation has undergone a transformation since 2009, including:

1) retirement of over 3,000 megawatts (MW) of coal fired power plants, which is 27% of the NC coal fleet.
2) increased use of natural gas combined cycle (NGCC) plants.
3) North Carolina legislation to promote renewable energy (RE).

- Solar, hydroelectric and wind power represented 10% of North Carolina's electricity generation in 2018.
- Avoided GHG emissions due to RE power are estimated at 5.26 MMT CO_2e for 2018.
- Emissions from imported electricity have decreased by 31% since 2005.
- If the carbon reduction goal outlined in SL 2021-165 is achieved by 2030 as required, the Electricity Generation sector will see a 67% overall decrease in gross GHG emissions compared to 2005 levels.

➢ **Transportation**

- Transportation sector emissions are significantly higher than estimated in the previous inventory, reflecting the impact of the new onroad vehicle emissions estimation methodology that utilizes EPA's state-of-the-science emissions modeling system.
- The Transportation sector is the largest emissions sector and represents about 36% of all GHG emissions.
- Emissions from the Transportation sector decreased by an estimated 3% from 2005 to 2018.
- Onroad light-duty gasoline vehicles represent 72% of total Transportation sector GHG emissions in 2018, while onroad medium/heavy-duty diesel vehicles are the next largest contributor (16%).
- While not captured in this inventory, national projections for gasoline and diesel vehicle emissions under the 2020 Corporate Average Fuel Economy (CAFE) and GHG standards suggest a notable decrease in GHG emissions.
- EPA estimates that 2021 promulgated light-duty vehicle GHG standards will achieve an additional national 6% reduction in CO_2, 5% reduction in CH_4, and 5% reduction in N_2O emissions in 2030 relative to the existing light-duty vehicle standards.[7]

➢ **Residential, Commercial, and Industrial**

- RCI emissions represent 13% of all GHG emissions.
- Residential sector emissions from total energy use have decreased by 25% between 2005 and 2018, while North Carolina's population grew by 19% over that time.
- GHG emissions from fuel combustion in the Commercial sector have increased by 3% due to shifts in the economy.
- Industrial fuel combustion emissions have decreased by 27% since 2005.

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[7] EPA, "Revised 2023 and Later Model Year Light-Duty Vehicle Greenhouse Gas Emissions Standards, Final Rule," 86 FR 74434, December 20, 2021.

- GHG emissions from Industrial Processes have doubled since 2005, mainly due to increased emissions of HFCs and PFCs resulting from their use as substitutes for ozone-depleting substances (ODS).

➢ **Land Use, Land Use Change, and Forestry**

- LULUCF sector carbon sequestration is greater than estimated in the previous inventory, which reflects larger estimates of North Carolina forest carbon stocks (as estimated by the U.S. Forest Service (USFS)) and the incorporation of estimates for additional LULUCF sector subcategories (e.g., Urban Trees).
- Forests, natural lands, and agricultural lands sequestered an estimated 42 MMT of CO_2 or 26% of total gross GHG emissions in 2018.
- Carbon storage in wood products and landfills is estimated to be a significant carbon sink in North Carolina (31% of the total 2018 sink).

1.3 North Carolina Climate Initiatives

1.3.1 State Executive Orders (EOs)

Governor Roy Cooper issued three EOs that set goals for North Carolinians to address climate impacts by mitigating GHG emissions and improving carbon sequestration. On October 29, 2018, the Governor signed EO-80 (North Carolina's Commitment to Address Climate Change and Transition to a Clean Energy Economy) that established the following goals for 2025 in the State:[8]

- Reduce statewide greenhouse gas emissions to 40% below 2005 levels;
- Increase the number of registered, zero-emission vehicles ("ZEVs"; individually, "ZEV") to at least 80,000; and
- Reduce energy consumption per square foot in state-owned buildings by at least 40% from fiscal year 2002-2003 levels.

June 9, 2021, Governor Cooper issued EO-218 (Advancing North Carolina's Economic and Clean Energy Future with Offshore Wind) promoting the development offshore wind power in North Carolina. The EO establishes the following goals for the State:[9]

- Develop 2.8 gigawatts (GW) of offshore wind energy resources off the North Carolina coast by 2030 and 8.0 GW by 2040.

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[8] State of North Carolina, Governor Roy Cooper, Executive Order No. 80, "North Carolina's Commitment To Address Climate Change And Transition To A Clean Energy Economy," October 29, 2018, https://governor.nc.gov/media/967/open.

[9] State of North Carolina, Governor Roy Cooper, Executive Order No. 218, "Advancing North Carolina's Economic and Clean Energy Future with Offshore Wind" June 9, 2021, https://files.nc.gov/governor/documents/files/EO218-Advancing-NCs-Economic-Clean-Energy-Future-with-Offshore-Wind.pdf.

January 7, 2022, Governor Cooper signed EO-246 (North Carolina's Transformation to A Clean, Equitable Economy) that establishes the following additional GHG emission reduction goals for the State:[10]

- Reduce statewide GHG emissions to at least 50 percent below 2005 levels by 2030 and achieve net-zero emissions as soon as possible, no later than 2050; and
- Increase the total number of registered ZEVs to at least 1,250,000 by 2030 and increase the sale of ZEVs so that 50 percent of in-state sales of new vehicles are zero-emission by 2030.

This and the previous GHG emissions inventory and forecast reports have been prepared to understand the sector-level baseline emissions to support development of GHG mitigation and carbon sequestration measures needed to achieve these goals.

1.3.2 Carbon Plan for North Carolina

On October 13, 2021, Governor Cooper signed bipartisan legislation SL 2021-165 (House Bill 951) that authorizes the NCUC to:

- Take all reasonable steps to achieve a 70% reduction in CO_2 emissions emitted in the State from electric public utilities from 2005 levels by the year 2030, and carbon neutrality by the year 2050,[11]
- Authorize performance-based regulation of electric public utilities,
- Proceed with rulemaking on securitization of certain costs and other matters, and
- Allow potential modification of certain existing power purchase agreements with eligible small power producers.

Part I, Section 1.(1) of SL 2021-165 requires the NCUC to "Develop a plan, no later than December 31, 2022, with the electric public utilities, including stakeholder input, for the utilities to achieve the authorized reduction goals, which may, at a minimum, consider power generation, transmission and distribution, grid modernization, storage, energy efficiency measures, demand-side management, and the latest technological breakthroughs to achieve the least cost path consistent with this section to achieve compliance with the authorized carbon reduction goals (the "Carbon Plan"). The Carbon Plan shall be reviewed every two years and may be adjusted as necessary in the determination of the Commission and the electric public utilities." The electric public utilities affected by SL 2021-165 include Duke Energy Progress and Duke Energy Carolinas.[12]

This inventory report presents total GHG emissions associated with electricity generation by all entities (i.e., investor-owned utilities, independent power producers, municipalities, and electric cooperatives) in North Carolina, and all GHG pollutants combined. The Carbon Plan will only address CO_2 emissions from the State's investor-owned utilities (i.e., Duke Energy Progress and Duke Energy Carolinas). This report provides an initial estimate of the impact associated with the

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[10] State of North Carolina, Governor Roy Cooper, Executive Order No. 246, "North Carolina's Transformation To A Clean, Equitable Economy," January 7, 2022, https://governor.nc.gov/media/2907/open.
[11] SL 2021-165 allows 5% of the 2050 CO_2 reductions to be met with offsets.
[12] For purposes of Part I, Section 1.(1) of SL 2021-165, "electric public utility" means any electric public utility as defined in G.S. 62-3(23) serving at least 150,000 North Carolina retail jurisdictional customers as of January 1, 2021.

2030 CO_2 emission reduction target incremental to the 2030 baseline emissions. Appendix D provides an initial estimate of 2005 baseline CO_2 emissions associated with facilities subject to SL 2021-165. In 2005, emissions associated with the affected facilities are estimated at 68.39 MMT CO_2. To achieve the 70% reduction target, CO_2 emissions associated with these facilities would need to reduce to 20.52 MMT CO_2.

Once the Carbon Plan is approved by the NCUC, information will be available to better understand the generation technology and fuel mix that will need to be implemented to achieve the SL 2021-165 targets which may affect the emission estimates. In addition, any demand-side management measures that are included in the plan may also impact emission projections for the RCI Combustion sectors.

1.4 2019 Inventory Report Revisions

This report revises the previous North Carolina GHG inventory report that was released in 2019. Because of the resources that are required to develop a comprehensive GHG emissions inventory, this report includes revised emission estimates for a subset of the complete list of GHG source categories. For the following source categories, this revised inventory replaces the previous estimates with estimates based on the most recent information available:

- Electricity Generation and Use;
- Transportation;
- Residential, Commercial, and Industrial (RCI) Fuel Combustion; and
- Land Use, Land Use Change, and Forestry (LULUCF).

These "priority" source categories were selected for updating because they are the largest contributors to net 2017 emissions in the comprehensive inventory released in 2019. For these priority source categories, the North Carolina Division of Air Quality (DAQ) utilized a set of emissions estimation improvements relative to the previous inventory, which result in the Transportation and LULUCF sectors exhibiting significantly higher emission/sink estimates than the previous inventory. For the Transportation sector, the DAQ is now using EPA's state-of-the-science emissions modeling system to estimate onroad vehicle emissions.[13] For the LULUCF sector, improvements include incorporating newly released EPA estimates that reflect larger estimates of North Carolina forest carbon stocks (as estimated by the USFS) and EPA estimates for additional LULUCF sector subcategories (e.g., Urban Trees).

1.5 Emission Sources Included in the Inventory

North Carolina's GHG emissions inventory covers all major 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

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[13] EPA, "MOVES3: Latest Version of Motor Vehicle Emission Simulator," available from https://www.epa.gov/moves/latest-version-motor-vehicle-emission-simulator-moves, accessed September 2021.

Processes, and Waste Management activities.[14] 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.

The 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 in the LULUCF sector.[15] 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.)

Gross CH_4 and N_2O emissions from biomass combustion are included in the inventory within the relevant consumption sector (e.g., Residential/Commercial/Industrial combustion). However, 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, Appendix C presents gross CO_2 emissions from biomass combustion in North Carolina and provides additional discussion on the treatment of CO_2 emissions from biomass combustion.

1.6 GHG Emissions Estimation Methods

For the Transportation sector, the latest version of EPA's Motor Vehicle Emissions Simulator Model (MOVES3) was used to calculate historic and projected GHG emissions. For all other sectors, both historical 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.[16] The SIT automates and adapts 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.

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[14] 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.

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

[16] EPA, "State Inventory and Projection Tool," https://www.epa.gov/statelocalenergy/download-state-inventory-and-projection-tool, accessed November 2020.

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 utilize data obtained from third party vendors (e.g., fertilizer application). 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. 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."

1.7 Reference Case Projection

The projection of the GHG inventory includes all sectors that were estimated for the historical 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 identified at this time. This reference case "baseline" projection can be used to evaluate the impact of future scenarios with policies, programs, or rules that increase or decrease emissions.

The baseline projection does not include recently adopted and future federal and State GHG mitigation and carbon sequestration measures. At the federal level, examples include 1) GHG emission standards for passenger cars and light-duty trucks for 2023 through 2026 recently adopted by EPA, 2) proposed CAFE standards for light-duty vehicles, and 3) phasedown of HFCs.[17,18,19] At the State level, examples include 1) control of CO_2 emissions from power plants (see Section 1.6); 2) increase in the use of RE, energy efficiency, and storage; 3) increase in the use of electric vehicles; 4) livestock manure management; and 5) sequestration of carbon by natural and working lands. Voluntary emission reduction measures taken by the private sector and local and state government will also be captured in the future as the consumption of fossil fuels changes based on demand. Future inventories will incorporate any final regulatory changes.

1.8 Structure of the Report

The remainder of this report is divided into two sections. The first section is an analysis of the key GHG-emitting 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 GWPs, and Appendix C discusses the treatment of CO_2 emissions from biomass combustion. Appendix D of

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[17] EPA, "Revised 2023 and Later Model Year Light-Duty Vehicle Greenhouse Gas Emissions Standards, Final Rule," 86 FR 74434, December 20, 2021.
[18] "Corporate Average Fuel Economy Standards for Model Years 2024–2026 Passenger Cars and Light Trucks, Proposed Rule" 86 FR 49602, September 3, 2021.
[19] "Reducing HFCs, AIM Act," background information available from https://www.epa.gov/climate-hfcs-reduction/aim-act, accessed January 2022.

this report provides an initial estimate of 2005 baseline CO_2 emissions associated with facilities subject to SL 2021-165 (House Bill 951).

2.0 Trends in Greenhouse Gas Emissions

This section of the report provides summary tables and figures, trend analysis, and detailed information on key source sectors impacting North Carolina's GHG emissions and carbon sinks from 1990 through 2030. This analysis uses 2005 as the baseline year of the inventory to evaluate emissions reductions because it is the most common baseline reporting year used in regard to national, multi-state, and North Carolina-specific GHG emissions reduction policies. For completeness, long-term trend analysis references back to 1990. The last year of comprehensive historical GHG emissions data in the SIT is 2018. Projections of GHG emissions from 2019 to 2030 are discussed in Section 2.10.

2.1 North Carolina GHG Trends from 1990 to 2018

Figure 2-1 presents North Carolina's gross GHG emissions from 1990 through 2018 for all source sectors. Emissions of GHGs peaked in 2007 and began to decline rapidly after 2010, primarily due to: (1) shifts in the types of fuel used and (2) decreases in the amount of fuel burned by the Electricity Generation and Use and RCI Combustion sectors. Since the 2005 baseline year, gross GHG emissions have dropped by 16% - from a total of 190 MMT CO_2e in 2005 to 159 MMT CO_2e in 2018.

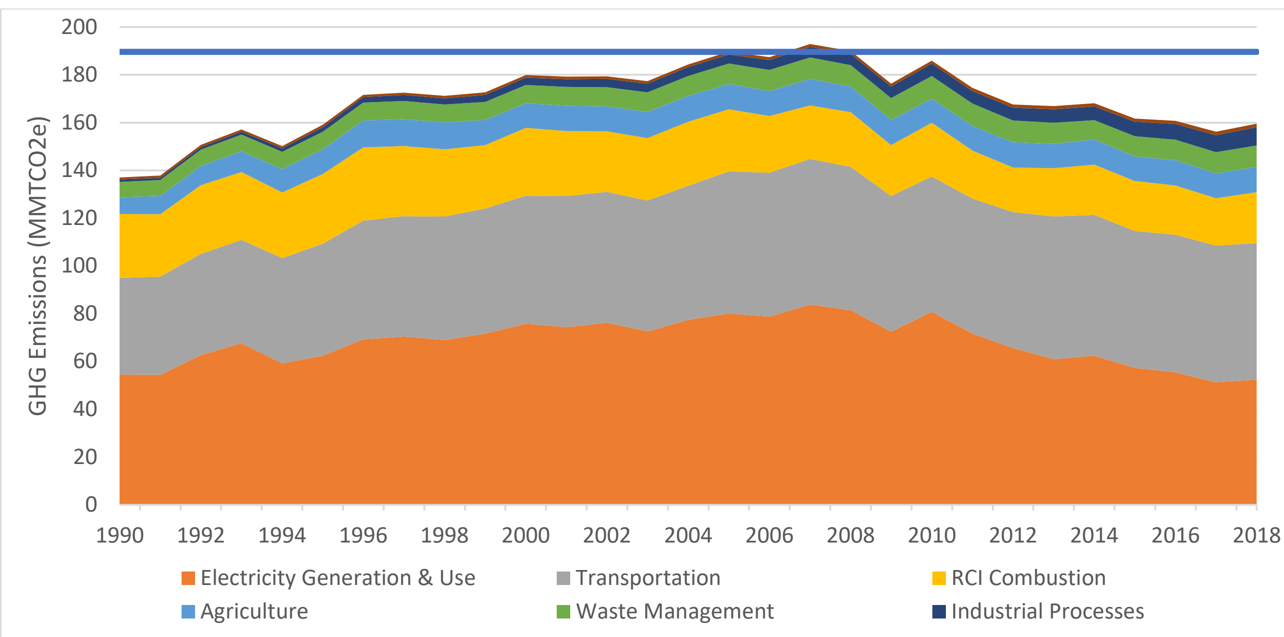

Figure 2-1: North Carolina Gross GHG Emissions Trends, 1990–2018

2.2 Gross GHG Emissions by Source Sector

Figure 2-2 shows the gross GHG emissions contributed by each source sector in 2018. Transportation is the largest source sector at 36% followed by Electricity Generation and Use at 33%, and RCI

Combustion at 13%. Together, combustion activities contribute to over 80% of the total statewide gross GHG emissions.

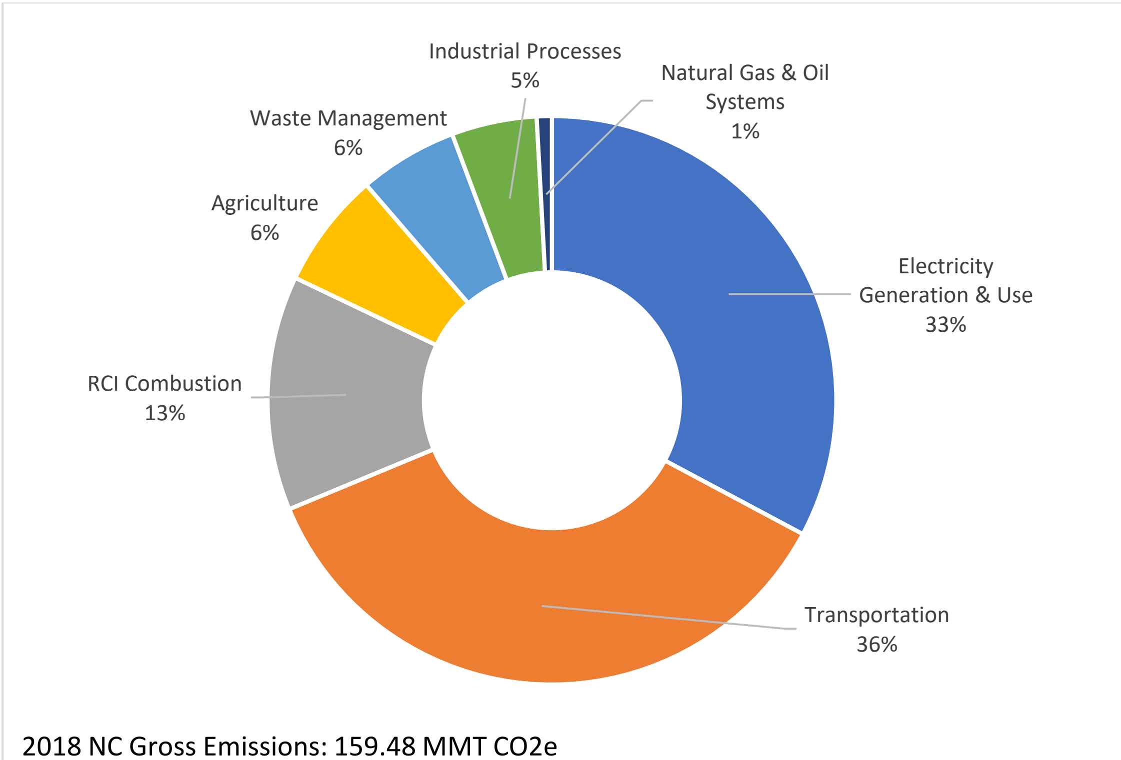

Figure 2-2: Percentage of North Carolina 2018 GHG Emissions by Source Sector

While these three sectors are the largest emitters, in total, they experienced an overall 21% reduction in GHG emissions between 2005 and 2018, with the largest reduction occurring in the Electricity Generation and Use sector, as shown in Table 2-1.

Table 2-1: Change in North Carolina GHG Emissions by Source Sector, 2005-2018

Source Sector	2005 GHG Emissions (MMT CO_2e)	2018 GHG Emissions (MMT CO_2e)	Change in GHG Emissions
Electricity Generation & Use	80.15	52.32	-35%
RCI Combustion	26.00	21.28	-18%
Transportation	59.36	57.31	-3%
Agriculture	10.65	10.52	-1%
Waste Management	8.52	8.94	5%
Industrial Processes	3.83	7.73	102%
Natural Gas Systems	1.17	1.37	17%
Gross Emissions	**189.68**	**159.48**	**-16%**

Note: Totals may not equal exact sum of subtotals shown in this table due to independent rounding.

The emissions reductions achieved in the Electricity Generation and Use and RCI Combustion sectors are primarily the result of switching from coal to natural gas combustion. Although emissions decreased less in the Transportation sector, the decline should be compared to the significant increase in vehicle miles traveled (VMT) that occurred over this period (i.e., the VMT increase was offset by the impact of vehicle and fuel efficiency standards). Emissions from Waste Management, Industrial Processes, and Natural Gas Systems sectors increased from the 2005 baseline. These increases are due to increased population, more use of non-ODS for refrigeration and cooling, and increased transmission/distribution of natural gas.[20,21]

Figure 2-3 presents the long-term GHG emissions trends separately for each sector from 1990 to 2018. The figure illustrates an increase in emissions from 1990 to 2007 for all sectors except RCI combustion, which shows a general decline starting in the mid-1990's through 2012. After 2007, there is a large drop in emissions from the Electricity Generation/Use sector (see Section 2.7 for a more detailed discussion of trends in this sector). The other sectors show increasing emissions trends. Post-1990 emission increases in the Transportation sector have resulted in this sector having the largest GHG emissions in each year since 2015 (Section 2.9 provides additional discussion of trends in this sector).

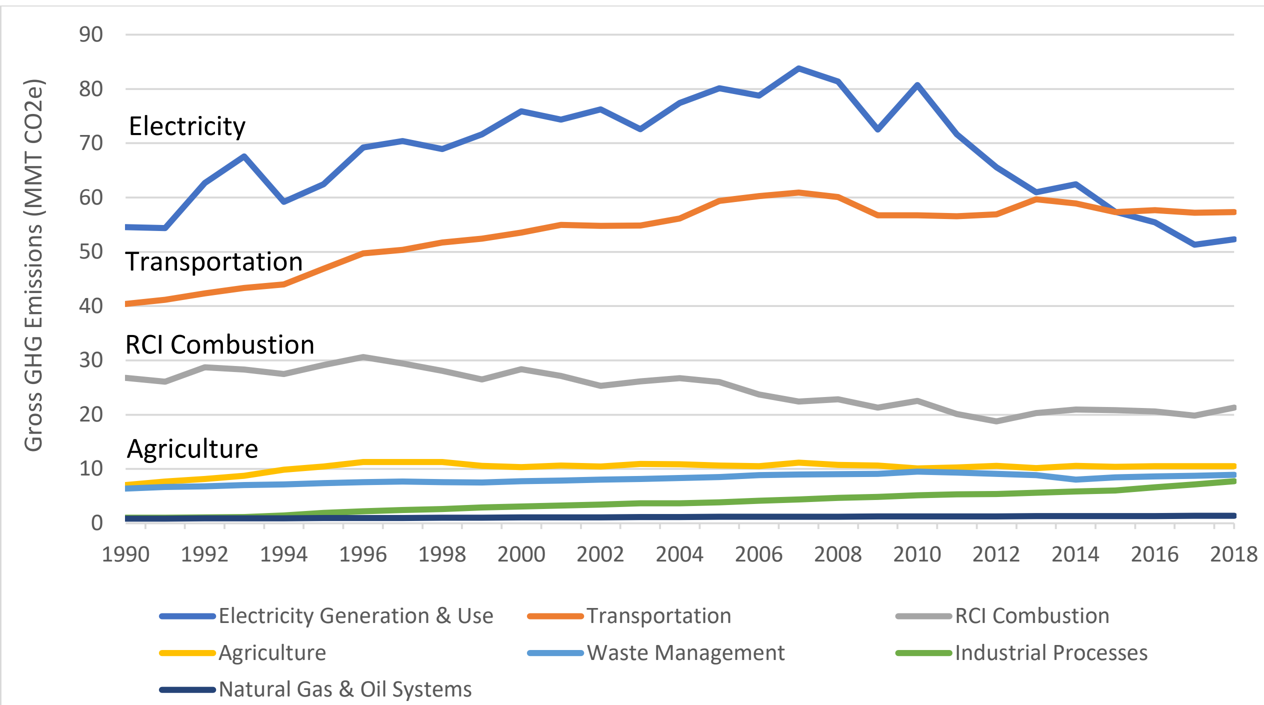

Figure 2-3: North Carolina GHG Emissions Trends by Source Sector, 1990-2018

[20] HFCs and PFCs are synthetic chemicals produced as alternatives for the ozone-depleting chlorofluorocarbons (CFCs) in response to the phase out of CFCs under the Montreal protocol of 1987. (See https://www.epa.gov/ozone-layer-protection/addressing-ozone-layer-depletion for more information.)

[21] Natural gas transmission/distribution emissions are not updated in this revised inventory. These emissions are estimated as a function of various factors such as pipeline miles, pipeline construction materials, and number of compressor stations (not based on the volume of gas distributed). Although this sector is not a significant source of GHG emissions relative to total statewide GHG emissions, the DAQ recognizes that natural gas use has increased in the State in recent years and will evaluate this sector in a future revision to this report.

2.3 Gross GHG Emissions by Gas Type and Fuel Type

The contribution of each gas relative to North Carolina's total gross GHG emissions in 2018 is presented in Figure 2-4. Carbon dioxide is emitted in much larger amounts than the other GHGs combined. However, the GWP for the other GHGs, which incorporates both atmospheric lifetime and ability to trap heat, makes them significant contributors as well. See Appendix B for more information on GWPs.

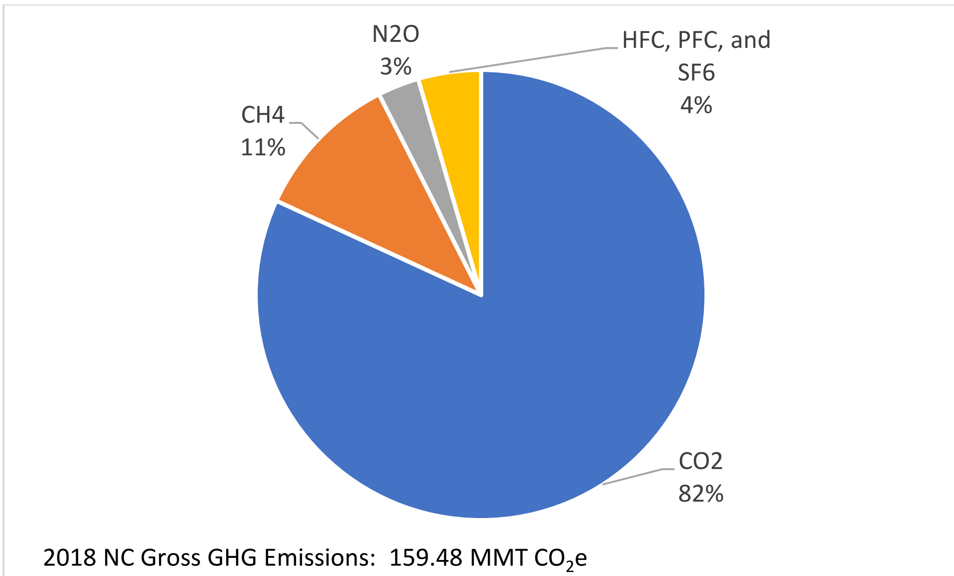

Figure 2-4: Percentage of North Carolina 2018 GHG Emissions by Gas Type

The primary source of CO_2 emissions in North Carolina is the combustion of fossil fuels. This includes fossil fuel combustion in the Electricity Generation, RCI Combustion, and Transportation sectors. Figure 2-5 presents North Carolina's CO_2 emissions from fossil fuel combustion for each fuel type. The figure indicates significant changes in fuel use over time. These changes resulted in a 21% reduction in CO_2 emissions from combustion of all fossil fuels between 2005 and 2018.

North Carolina's electricity generators and industries have significantly reduced their use of coal in favor of less expensive natural gas combustion. Figure 2-5 illustrates this transition from coal to natural gas between 1990 and 2018. Since 2005, emissions from coal combustion have dropped by 60% while emissions from natural gas have more than doubled during this same period. Emissions from petroleum combustion have decreased by 9% between 2005 and 2018.

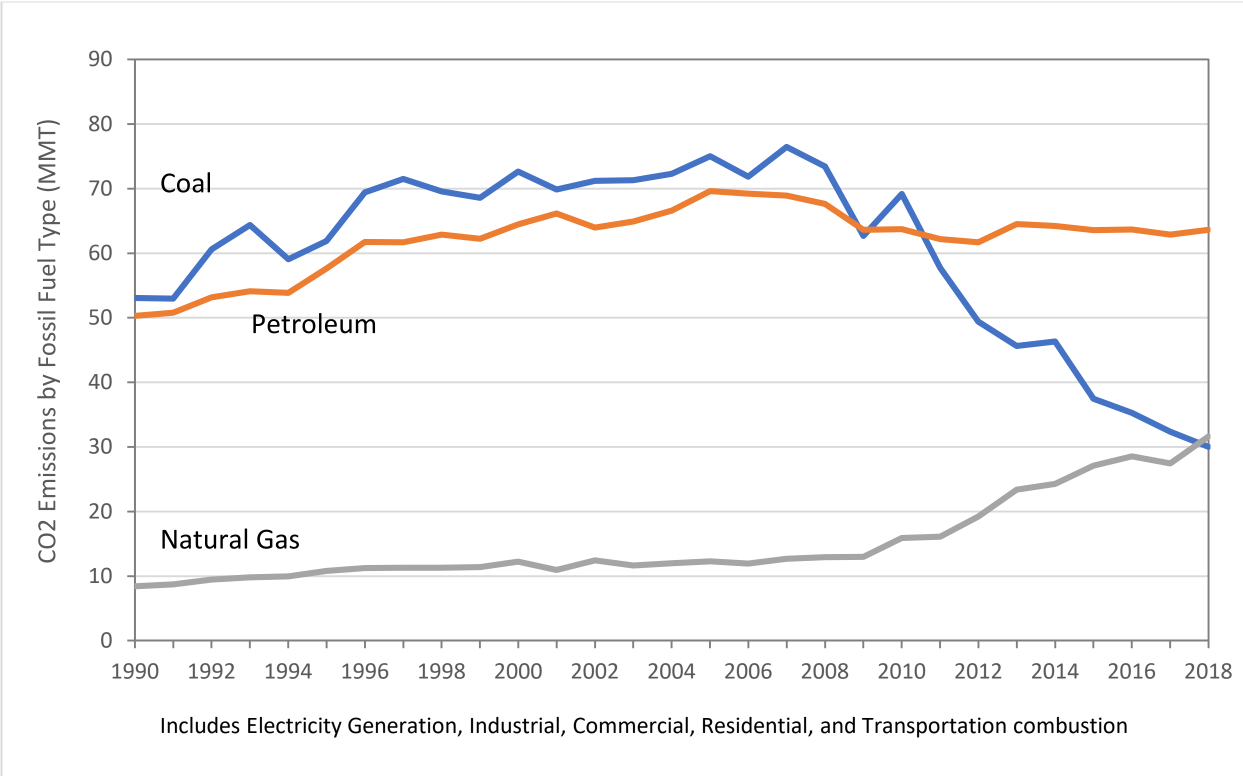

Figure 2-5: North Carolina CO_2 Emissions Trends in Fossil Fuel Combustion, 1990-2018

2.4 Gross GHG Emissions by Population and Gross State Product

It is important to understand the impact of North Carolina's growing population and thriving economy has on GHG emissions over time. From 2005 to 2018, North Carolina's real GSP increased by 24% and population increased by 19%.[22,23] Figure 2-6 compares the 2005-2018 trends in: (1) population and real GSP; and (2) gross GHG emissions per capita and per dollar of real GSP.

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[22] North Carolina's GSP in 2012 dollars obtained from the North Carolina Office of State Budget and Management.
[23] North Carolina data provided by North Carolina Office of State Budget and Management, obtained May 2021.

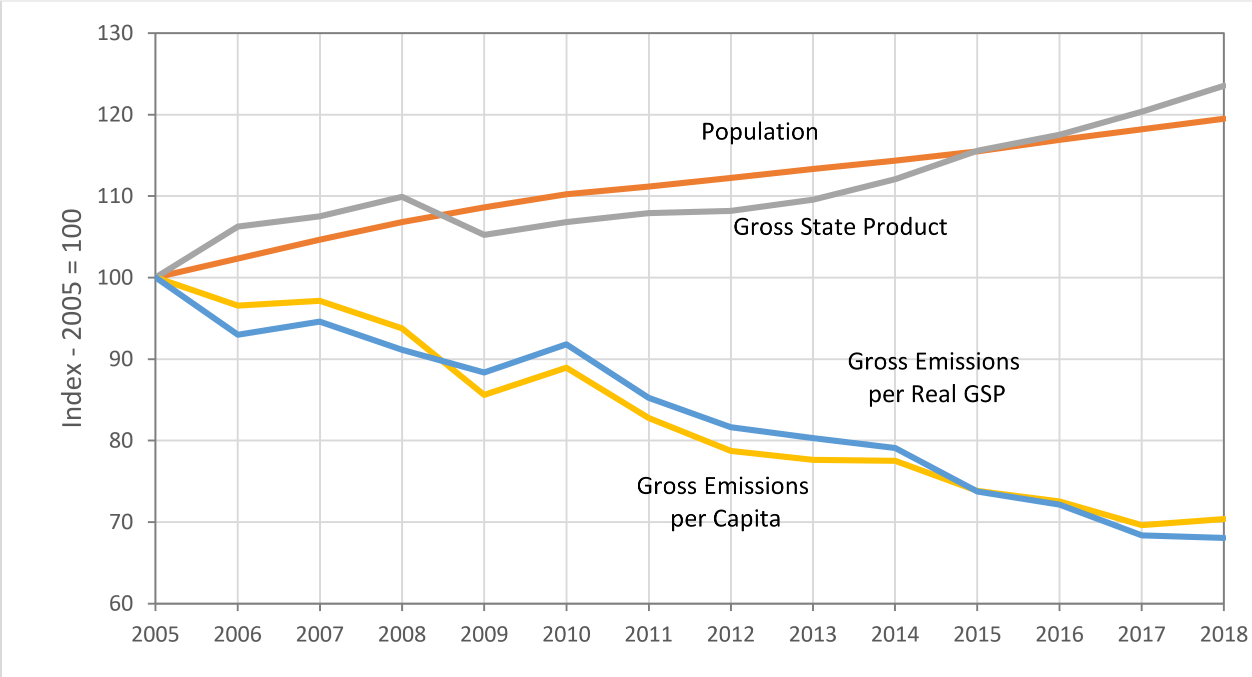

Figure 2-6: North Carolina GHG Emissions Relative to Population and GSP, 2005-2018

As shown in the figure, population increased steadily during this period. GSP increased from 2005 up through 2008, then declined due to the Great Recession. GSP was slow to recover through 2012 then climbs more significantly thereafter. Emissions on both a per capita basis and a per real dollar GSP basis decline steadily during much of the time period, with a brief increase between 2009 and 2010. There is an overall decrease of 30% in emissions on a per capita basis and a 32% reduction on a per real dollar GSP basis in 2018 relative to 2005 levels. This analysis demonstrates that State policies [e.g., Clean Smokestacks Act (CSA), Renewable Energy and Energy Efficiency Portfolio Standard (REPS)], federal regulations [CAFE and GHG standards, Electricity Generating Unit Mercury and Air Toxics Standards (MATS)] and market forces (e.g., low natural gas and declining solar technology prices) have resulted in a lower-carbon economy in North Carolina.[24,25,26,27]

2.5 Changes from Previous Inventory

Emissions presented in this report are compared to emissions presented in the January 2019 report in Table 2-2 for selected historical years, and Table 2-3 for projection years 2025 and 2030. In the 2019 report, 2017 and 2018 values were short-term projections. The Transportation and LULUCF

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[24] Session Law 2002-4, "An Act to Improve Air Quality in the State by Imposing Limits on the Emission of Certain Pollutants from Certain Facilities that Burn Coal to Generate Electricity and to Provide For Recovery by Electric Utilities of the Costs of Achieving Compliance with those Limits", June 20, 2002, https://www.ncleg.net/Sessions/2001/Bills/Senate/PDF/S1078v5.pdf.

[25] Session Law 2007-397, "North Carolina's Renewable Energy and Energy Efficiency Portfolio Standard (REPS), August20, 2007, http://www.ncuc.commerce.state.nc.us/reps/reps.htm.

[26] NHTSA, Corporate Average Fuel Economy, https://www.nhtsa.gov/laws-regulations/corporate-average-fuel-economy.

[27] EPA, MATS, https://www.epa.gov/mats/regulatory-actions-final-mercury-and-air-toxics-standards-mats-power-plants.

sectors are mostly responsible for the major change in emissions relative to the previous report. These are two of the four sectors for which the emissions estimation methodologies and/or activity data have been updated and further refined in this report. Transportation sector emissions are significantly higher than estimated in the previous inventory, reflecting the impact of the new onroad vehicle emissions estimation methodology that utilizes EPA's state-of-the-science emissions modeling system.[28] For 2005 and 2017, emissions for the Transportation sector increased by 7.6% and 17.3%, respectively. For these same years, carbon sinks for the LULUCF sector increased by 14.2% and 22.2%, respectively. The LULUCF sector changes are result of continued refinements to data underlying the SIT's LULUCF module, as well as increased comprehensiveness of source category coverage in the LULUCF sector.[29] Overall, for 2005 and 2017, gross emissions increased by 2.7% and 4.0%, respectively. Net emissions increased by 0.2% in 2005 and decreased by 1.3% in 2017. The improvements to the activity data and methodologies for the Transportation and LULUCF sectors presented in this report provide more detail to support development of GHG mitigation/carbon storage policies for these sectors. For the projection years, there is a significant decrease in emissions for the Electricity Generation/Use sector due to updated emissions projections, which forecast lower coal use compared to the projections used for the previous report.

Relative to the 2005 baseline, statewide gross and net emissions in 2030 are estimated to decline by 25.6% and 35.0%, respectively. In the previous January 2019 report, statewide gross and net emissions in 2030 were estimated to decline by 23.5% and 29.4%, respectively, relative to the 2005 baseline.

Table 2-2: Change in Emissions from January 2019 to January 2022 Report for Historical Years (2005, 2017, and 2018, in MMT CO_2e)

Emissions Year	2005			2017			2018		
Sector	2019 Rpt.	2022 Rpt.	% Change	2019 Rpt.	2022 Rpt.	% Change	2019 Rpt.	2022 Rpt.	% Change
Electricity Generation and Use	79.37	80.15	1.0%	52.60	51.29	-2.5%	46.16	52.32	13.3%
RCI Fuel Combustion	26.02	26.00	-0.1%	20.92	19.83	-5.2%	21.92	21.28	-2.9%
Transportation	55.19	59.36	7.6%	48.72	57.18	17.3%	47.58	57.31	20.5%
Agriculture	10.65	10.65	0.0%	10.53	10.53	0.0%	10.52	10.52	0.0%
Waste Management	8.52	8.52	0.0%	8.77	8.77	0.0%	8.94	8.94	0.0%
Industrial Processes	3.83	3.83	0.0%	7.18	7.18	0.0%	7.73	7.73	0.0%
Natural Gas and Oil Systems	1.17	1.17	0.0%	1.35	1.35	0.0%	1.37	1.37	0.0%
Gross Emissions	**184.74**	**189.68**	**2.7%**	**150.08**	**156.13**	**4.0%**	**144.22**	**159.48**	**10.6%**
Net Carbon Sinks - Land Use & Land Use Changes	-32.66	-37.29	14.2%	-34.03	-41.58	22.2%	-34.03	-42.13	23.8%

[28] EPA, "MOVES3: Latest Version of Motor Vehicle Emission Simulator," available from https://www.epa.gov/moves/latest-version-motor-vehicle-emission-simulator-moves, accessed September 2021.
[29] For example, the previous LULUCF sector inventory excluded estimates for Urban Trees.

Emissions Year	2005			2017			2018		
Sector	2019 Rpt.	2022 Rpt.	% Change	2019 Rpt.	2022 Rpt.	% Change	2019 Rpt.	2022 Rpt.	% Change
Net Emissions	**152.08**	**152.39**	**0.2%**	**116.06**	**114.56**	**-1.3%**	**110.20**	**117.35**	**6.5%**

Table 2-3: Change in Emissions from January 2019 to January 2022 Report for Projection Years (2025 and 2030, in MMT CO_2e)

Emissions Year	2025			2030		
Sector	2019 Rpt.	2022 Rpt.	% Change	2019 Rpt.	2022 Rpt.	% Change
Electricity Use	40.59	41.08	1.2%	42.46	34.35	-19.1%
RCI Fuel Combustion	23.26	21.38	-8.1%	23.92	21.96	-8.2%
Transportation	41.00	52.42	27.9%	39.22	49.09	25.2%
Agriculture	10.47	10.47	0.0%	10.44	10.44	0.0%
Waste Management	10.17	10.17	0.0%	11.07	11.07	0.0%
Industrial Processes	11.31	11.31	0.0%	12.73	12.73	0.0%
Natural Gas and Oil Systems	1.47	1.47	0.0%	1.55	1.55	0.0%
Gross Emissions	**138.28**	**148.31**	**7.3%**	**141.37**	**141.18**	**-0.1%**
Net Carbon Sinks - Land Use & Land Use Changes	-34.03	-42.13	23.8%	-34.03	-42.13	23.8%
Net Emissions	**104.25**	**106.18**	**1.8%**	**107.35**	**99.05**	**-7.7%**

2.6 Comparison Between North Carolina and National Gross GHG Emissions

This section compares North Carolina's GHG emissions trends to national emissions trends. Note that the national GHG inventory includes source sectors that do not operate in North Carolina. Some of these source sectors are large, such as coal mining, cement production, and iron, steel and coke production. The U.S. data are taken from the "Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2018."[30]

North Carolina emits approximately 2.4% of the total U.S. gross GHG emissions, based on 2018 emissions data, as shown in Table 2-4. This table also indicates that North Carolina is achieving larger reductions in gross GHG emissions than the country as a whole.

Table 2-4: Comparison of Gross GHG Emissions for North Carolina and U.S., 2005-2018

Region	2005 GHG Emissions (MMT CO_2e)	2018 GHG Emissions (MMT CO_2e)	Percent Reduction 2005 to 2018	North Carolina Percentage of U.S. GHG Emissions in 2018
North Carolina	190	159	16%	2.4%
U.S.	7,392	6,677	10%	

[30] EPA, "Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2018," EPA 430-R-20-002, Washington, D.C., April 13, 2020.

This trend is further illustrated by Figure 2-7, which shows the percent reduction in gross GHGs relative to the 2005 baseline year for both North Carolina and the U.S for each year through 2018. As of 2018, North Carolina had reduced gross GHG emissions by 16% from the baseline year, while the U.S. achieved an 10% reduction from the baseline.

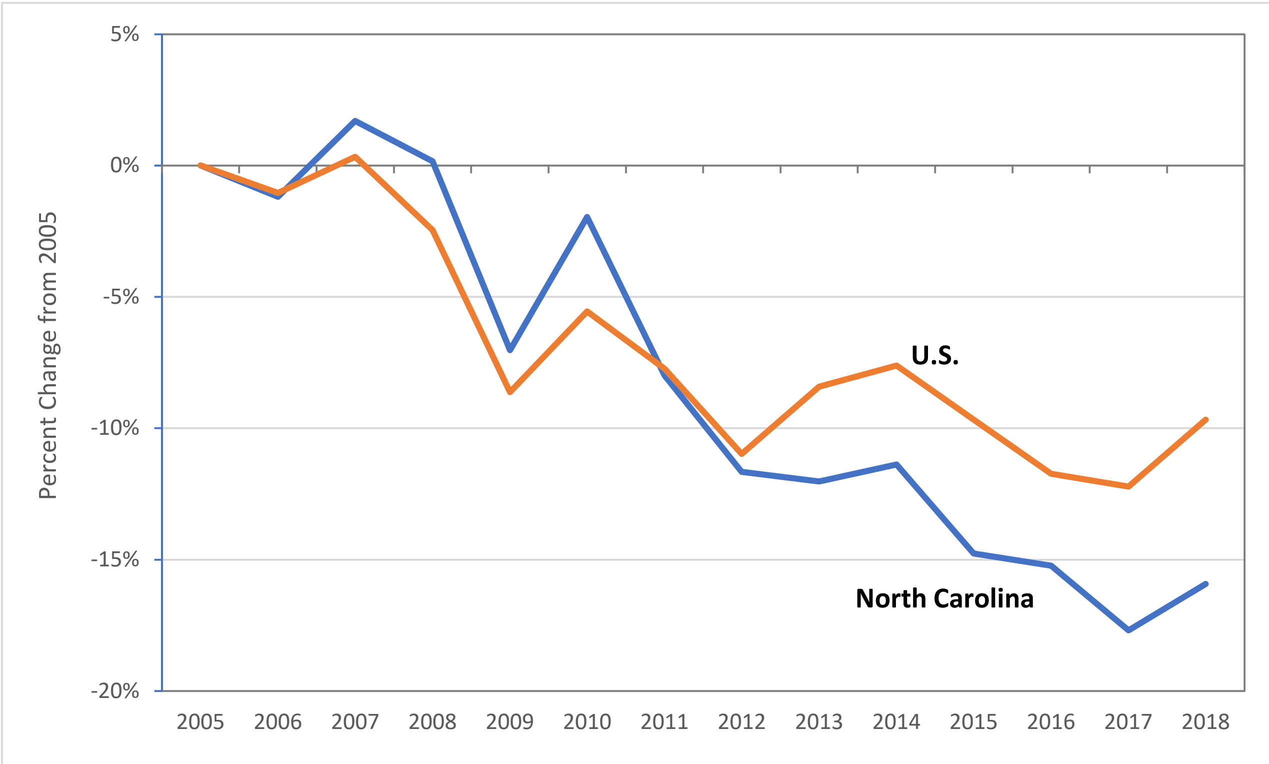

Figure 2-7: Percent Change in Gross GHG Emissions for North Carolina and U.S., 2005-2018

Table 2-5 compares changes in CO_2 emissions due to shifts in fossil fuel combustion for North Carolina and the U.S. Emissions from coal and petroleum combustion in the U.S. have dropped by 43% and 10% between 2005 and 2018, respectively. U.S. emissions from natural gas combustion increased by 38% during this same period of time. North Carolina has also changed its fossil fuel mix. North Carolina's 2005-2018 CO_2 emissions from coal combustion have dropped by 60%, significantly greater than the U.S. reduction, while emissions from natural gas have more than doubled. The overall changes in fossil fuel combustion result in a 12% reduction in CO_2 emissions for the U.S. and a 20% reduction in CO_2 emissions for North Carolina.

Table 2-5: CO_2 Emissions by Fossil Fuel Type for North Carolina and U.S., 2005-2018

	North Carolina CO_2 Emissions (MMT)			U.S. CO_2 Emissions (MMT)		
Fuel Type	**2005**	**2018**	**Percent Change**	**2005**	**2018**	**Percent Change**
Coal	75.0	30.0	-60%	2,111	1,209	-43%
Petroleum	69.6	63.6	-9%	2,462	2,211	-10%
Natural Gas	12.3	31.6	157%	1,167	1,612	38%

Total	156.9	125.2	-20%	5,740	5,031	-12%

The U.S. Energy Information Administration (EIA) estimates energy-related CO_2 emissions for each state.[31] Based on EIA estimates for 2018, North Carolina ranks 12th in the nation for energy-related CO_2 emissions as shown in Table 2-6. North Carolina's rankings for CO_2 emissions from each source sector are also displayed. While North Carolina ranks 12th in the nation for energy-related CO_2 emissions, it ranks 9th for population in 2018.[32] This high population makes North Carolina's 253 million British thermal units (MMBtu) energy consumed per person, lower than the national average of 305 MMBtu per capita.[33] North Carolina is ranked 7th in the nation for generating its own electricity while the CO_2 emissions from this sector are only ranked 13th in the nation. This indicates North Carolina's fossil fuel power plant fleet emits less CO_2 per megawatt-hour (MWh) compared to other high electricity generation states. North Carolina's costs for energy and electricity are also below the national average as shown in Table 2-7 by the rankings for total energy expenditures per capita of 45th and average residential retail price of electricity of 42nd in the nation.

Table 2-6: North Carolina's 2018 State Ranking of Energy-Related CO_2 Emissions

Sector	Units	Value	Ranking Compared to Other States*
Total Energy-Related CO_2 Emissions	MMT CO_2	**124.75**	**12**
Electric Power		*48.36*	*13*
Industrial		*10.72*	*27*
Commercial		*5.24*	*16*
Residential		*5.53*	*20*
Transportation		*54.90*	*9*

*Rank of 1 = highest in U.S.

Table 2-7: North Carolina's Most Recent State Ranking for Energy-Related Metrics

Metric	Date	Units	Value	Ranking Compared to Other States*
Total Energy Consumed per Capita	2019	MMBtu per capita	253	36
Total Energy Expenditures per Capita	2019	$ per capita	3,254	45
Net Electricity Generation	August 2021	thousand MWh	13,483	7
Average Residential Retail Price of Electricity	August 2021	cents/kWh	11.54	42

*Rank of 1 = highest in U.S.

[31] EIA, "Energy-Related CO_2 Emission Data Tables, Table 4," available from https://www.eia.gov/environment/emissions/state/, accessed December 2021 (energy-related CO_2 emissions refers to emissions released at the location where fossil fuels are combusted).
[32] U.S. Census Bureau, "Annual Estimates of the Resident Population for the United States, Regions, States, and Puerto Rico: April 1, 2010 to July 1, 2019," available from https://www.icip.iastate.edu/tables/population/states-estimates, accessed January 2022.
[33] EIA State Rankings: Total Energy Consumed per Capita, 2019 (MMBtu), https://www.eia.gov/state/data.php?sid=NC#EnergyIndicators.

2.7 Electricity Generation

Electricity Generation represents the second largest GHG emissions sector in North Carolina as shown earlier in Figure 2-2. Based on EIA data, North Carolina imports about an additional 10% of the electricity it consumes from power plants located outside the State.[34] This analysis assumes that all power generated in North Carolina is used in North Carolina, and the remaining electricity demand is met by imported power. It also accounts for line losses due to transmission and distribution.

2.7.1 Trends in North Carolina's Fossil Fuel Electricity Generation from 2005 to 2018

North Carolina's Electricity Generation sector has undergone drastic changes since 2005. Over 3,000 MW of coal-fired power plants were retired and were replaced with 3,600 MW of NGCC power plants between 2005 and 2018. This is primarily due to (1) increased supply of natural gas from shale formations, (2) lower natural gas fuel prices, and (3) increased environmental regulations (e.g., CSA, REPS, and MATS) on coal power plants. Figures 2-8 and 2-9 illustrate North Carolina's shift from coal to natural gas for Electricity Generation.[35]

Natural gas combustion emitted approximately 40% less CO_2 than coal combustion between 2005 and 2018.[36] In addition, NGCC plants are roughly 20% more efficient at generating electricity than traditional coal plants.[37] Therefore, NGCC power plants emit substantially less CO_2 than coal power plants for the same amount of electricity generation.[38]

Figure 2-8 indicates that coal represented 42% of the fossil fuel used to generate electricity in 2018 while Figure 2-9 indicates it represented 61% of the GHGs emitted. In the same year, natural gas plants generated 57% of the electricity while these plants emitted only 38% of the total GHG emissions.

Switching to NGCC power plants, which are both more efficient and lower emitting, contributed to an overall 35% reduction of GHG emissions from fossil fuel power plants between 2005 and 2018. During this same time period, fossil fuel electricity generation in North Carolina decreased by 8%.

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[34] EIA SEDS: 1960-2018, https://www.eia.gov/state/seds/seds-data-complete.php?sid=NC#Consumption. The carbon intensity of Imported Electricity is calculated using EPA's estimate of the average carbon intensity of generation in the SRVC region. See Section 3.1.5.
[35] EIA Form 923 Detailed Data, https://www.eia.gov/electricity/data/eia923/.
[36] On a heat content basis, natural gas combustion emits 40% less CO_2 than coal combustion.
[37] Refers to the efficiency of the thermodynamic cycle.
[38] This evaluation does not account for fugitive CH_4 emissions from natural gas piping at natural gas power plants. Emissions from transmission of natural gas to the plant are estimated under the Natural Gas and Oil Systems sector.

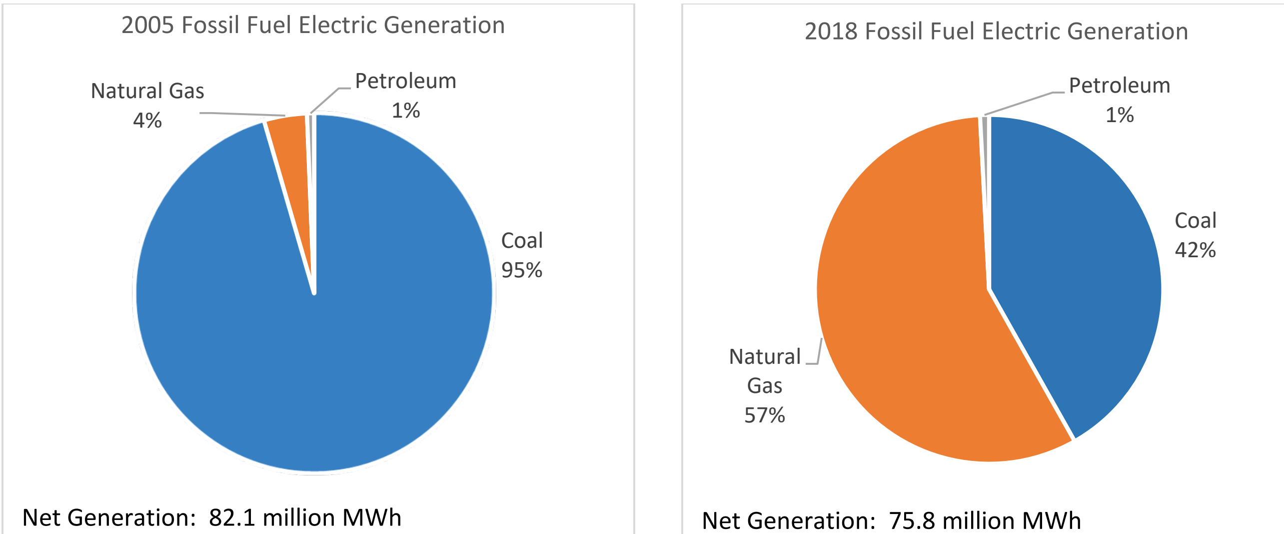

Figure 2-8: Changes in North Carolina Fossil Fuel Electricity Generation, 2005-2018

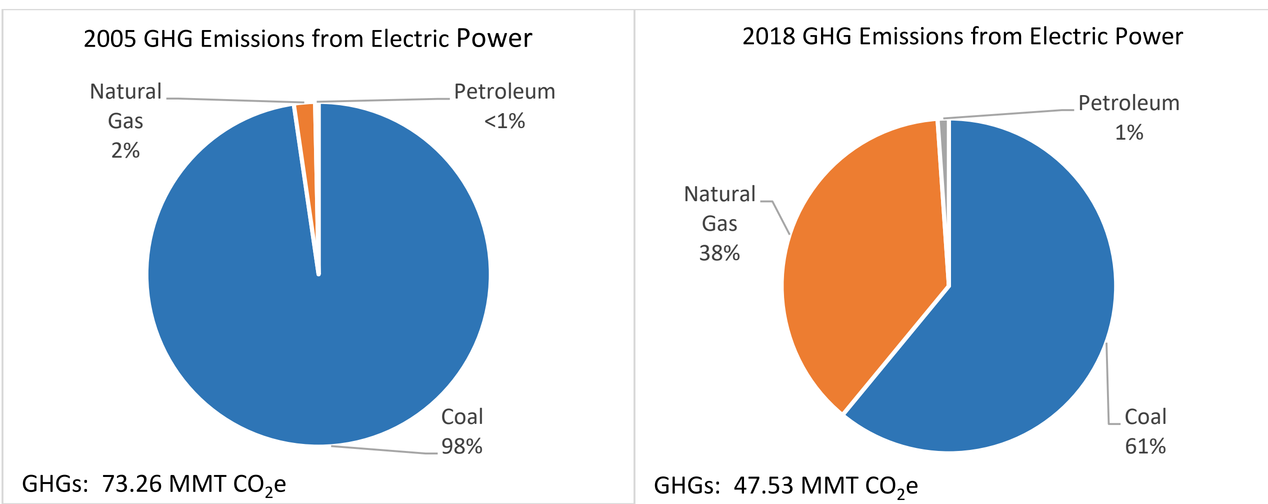

Figure 2-9: Changes in North Carolina GHG Emissions by Fossil Fuel Type, 2005-2018

2.7.2 Trends in North Carolina's Renewable Energy Generation

The shift in North Carolina's sources of electric power between 2005 and 2018 is shown in Figure 2-10, using MWhs of electricity generation as a metric. Fossil fuel electricity generation has decreased by 8% and nuclear has essentially remained the same. A substantial amount of RE generation occurred in 2018 relative to 2005: 5,999 MWh of solar and 543 MWh of wind. These new RE resources result in an increase in RE electricity generation from 4% by hydroelectric in 2005 to 10% by hydroelectric, solar, and wind combined in 2018.

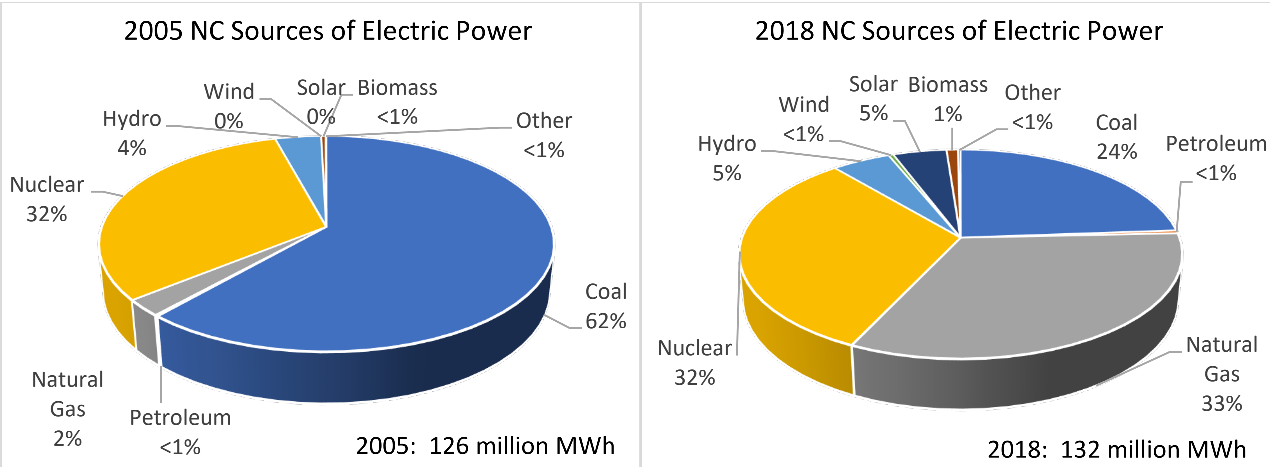

Figure 2-10: Changes in North Carolina Sources of Electricity Generation, 2005-2018

One driver of the increase in RE electricity generation is North Carolina's REPS, which became effective in 2007.[39] This law requires North Carolina's investor-owned utilities to obtain 12.5% of electricity demand from a mix of RE, biomass, and energy efficiency by 2021.

In order to quantify the impact of new RE generation on the GHG emissions inventory for the Electricity Generation sector, the GHGs that are not emitted as a result of using RE are estimated. These emissions are referred to as "avoided emissions." As shown in Table 2-8, avoided GHG emissions in North Carolina due to RE electric power is estimated to be 5.26 MMT CO_2e in 2018.[40]

Table 2-8: Avoided GHG Emissions Due to Use of Renewable Generation

Parameter	2005	2010	2011	2012	2013	2014	2015	2016	2017	2018
RE Net Generation (thousand MWh)	5,280	5,520	4.877	4,707	7,523	6,803	7,213	8,922	10,681	14,409
CO_2e Emission Factor (lb/MWh)	1,241.9	1,187.5	1,124.6	1,061.7	1,024.1	986.6	929.6	872.7	838.4	804.1
Avoided Emissions (MMT CO_2e)*	2.97	2.97	2.49	2.27	3.49	3.04	3.04	3.53	4.06	5.26

*Calculated using EPA eGRID GHG Emission factor for North Carolina and EIA Form 923 Net Generation.[41]

[39] For more information on the NC REPS, see http://www.ncuc.commerce.state.nc.us/reps/reps.htm.
[40] For this calculation, RE does not include biomass since biomass is not a zero-emitting source (see Appendix C for further discussion).
[41] EPA, Clean Air Markets Division, eGRID, available from https://www.epa.gov/egrid/emissions-generation-resource-integrated-database-egrid, accessed July 2021.

2.7.3 Trends in U.S. Electricity Generation

The U.S. Electricity Generation sector has undergone changes similar to North Carolina in both the use of fossil fuels and the increased use of RE. These shifts in generation type vary regionally. For example, the majority of wind power generated in the U.S. is located in the Midwestern States.

The shift in the sources of national electricity generation between 2005 and 2018 are shown in Figure 2-11. Nationally, coal use has decreased from 50% to 28% while natural gas use has increased from 19% to 35%. Petroleum use has decreased to 1%. Solar, wind, and geothermal energy combined have increased from 1% of total generation in 2005 to about 9% of total generation in 2018. Nuclear and hydroelectric generation have remained fairly constant. This shift in sources of electricity generation has resulted in an approximately 27% reduction in national GHG emissions from the power sector.

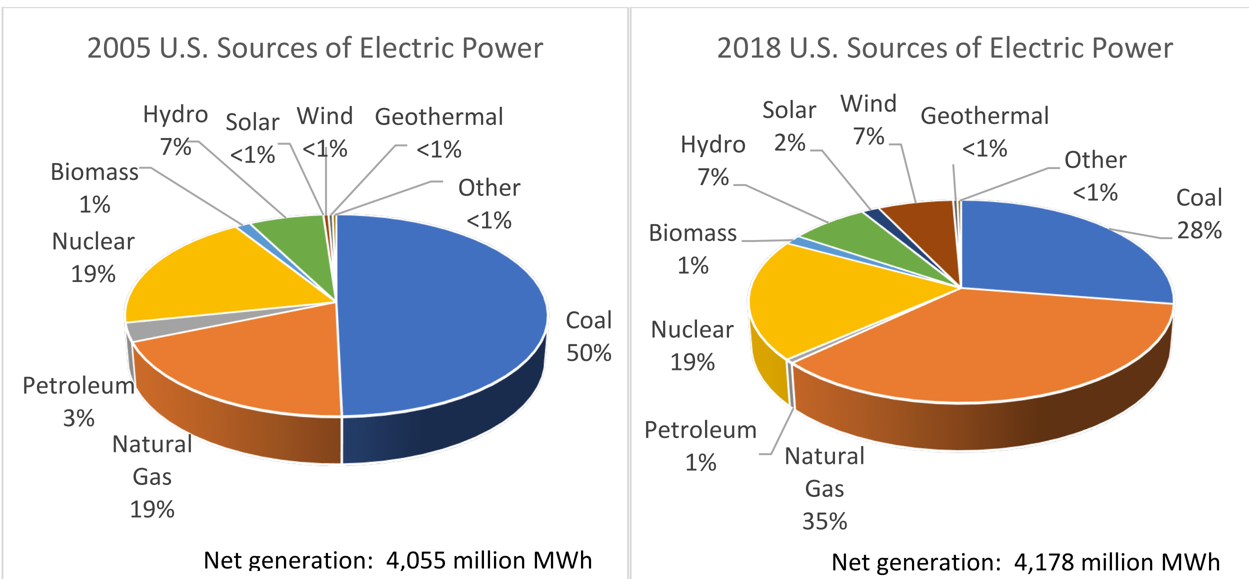

Figure 2-11: Changes in U.S. Sources of Electricity Generation, 2005-2018

2.8 Residential, Commercial, and Industrial

Key economic sectors that contribute GHG emissions include the RCI sectors. These sectors produce GHG emissions from (1) on-site fuel combustion and (2) the use of electricity to power homes, businesses, and manufacturing plants.[42] The sum of GHG emissions represents total energy used and allows policy makers and energy analysts to best evaluate the impacts that these economic sectors have on GHG emissions.

[42] Note that emissions for Electricity Consumption do not occur at the businesses or homes but occur at power plants supporting the regional electricity grid, and are referred to as "indirect emissions."

GHG emissions by RCI sector and energy source are presented in Table 2-9.[43] GHG emissions from electricity use contribute significantly to the total GHG emissions for these sectors, especially for the Residential and Commercial sectors.

Table 2-9 shows how these sectors' emissions profiles have changed over time. In 1990, the Industrial sector was the largest energy consuming sector and had the highest total energy use-related GHG emissions. By 2005, the Residential sector became the largest total energy consumer and GHG emitter in North Carolina. In 2018, this sector represented an estimated 39% of the emissions from total energy use in these three sectors.

Table 2-9: GHG Emissions from Total Energy Use by the RCI Sector (MMT CO_2e)

RCI Sector and Energy Source	1990	2005	2012	2015	2018	Change from 2005-2018
Industrial Total Energy Use	**36.15**	**32.07**	**24.36**	**22.31**	**20.86**	**-35%**
Fuel Combustion	*17.58*	*14.20*	*10.10*	*10.05*	*10.43*	*-27%*
Electricity Use	*18.57*	*17.88*	*14.26*	*12.26*	*10.43*	*-42%*
Commercial Total Energy Use	**18.94**	**31.28**	**28.83**	**26.66**	**24.02**	**-23%**
Fuel Combustion	*3.79*	*5.06*	*4.17*	*5.31*	*5.22*	*3%*
Electricity Use	*15.15*	*26.23*	*24.66*	*21.35*	*18.80*	*-28%*
Residential Total Energy Use	**25.07**	**38.86**	**33.46**	**31.08**	**29.13**	**-25%**
Fuel Combustion	*5.39*	*6.75*	*4.47*	*5.45*	*5.64*	*-16%*
Electricity Use	*19.68*	*32.11*	*28.99*	*25.63*	*23.50*	*-27%*
Total RCI Fuel Combustion	*26.76*	*26.00*	*18.74*	*20.81*	*21.28*	*-18%*
Total RCI Electricity Use	*53.40*	*76.21*	*67.91*	*59.24*	*52.73*	*-31%*
Total Energy Use	**80.16**	**102.21**	**86.65**	**80.05**	**74.01**	**-28%**

Note: Totals may not equal exact sum of subtotals shown in this table due to independent rounding.

Table 2-9 also includes the percent change in GHG emissions for each sector between 2005 and 2018. GHG emissions from total energy use decreased by 28% for all three sectors combined. This is primarily due to a 35% reduction in emissions from the Industrial sector. This decline in emissions is due to the decrease in North Carolina's manufacturing economy as well as federal Clean Air Act regulations. The table indicates that fuel combustion emissions from the Commercial sector grew by 3% since 2005, while emissions from electricity use in the Commercial sector have decreased by 28%. Residential sector emissions from total energy use have decreased by 25% since

[43] The electricity use emissions by consuming sector estimates in this table are not consistent with the Electricity Generation and Use sector emissions reported elsewhere in this report because of different emissions estimation procedures (e.g., in-state generation emission estimates use North Carolina electric power sector fuel consumption estimates and emission rates by fuel type, while the Table 2-6 estimates reflect North Carolina electricity consumption by sector, transmission/distribution line loss, and regional emission rates per MWh of electricity estimates).

2005, while North Carolina's population grew by 19% over that time.[44] This decline in emissions is the result of the introduction of more energy efficient appliances, lighting, and building codes.[45]

2.9 Transportation

Transportation is the largest GHG-emitting sector in North Carolina, representing approximately 36% of gross GHG emissions as shown in Figure 2-2. Therefore, understanding the factors that drive emissions from this sector is critical for GHG mitigation planning in North Carolina.

Emissions estimated for this sector include both "highway mobile" and "non-highway mobile" sources. Highway mobile sources are transportation vehicles that operate on public roadways, while non-highway mobile sources are vehicles and equipment that perform transportation and other functions in off-road settings. Alternative fuel vehicles are defined separately from other highway mobile sources to identify specific trends in use of non-conventional fuels. Table 2-10 displays some of the specific vehicle and equipment types included in each of these three major sub-sectors.

Table 2-10: Example Vehicle and Equipment Types included in Transportation Sector

Highway Mobile (~90% of sector emissions)	Non-Highway Mobile (~10% of sector emissions)		Alternative Fuel Vehicles (<1% of sector emissions)
Light-Duty Vehicles: Passenger Cars Passenger Trucks Heavy Duty Vehicles: Buses Commercial Trucks	Off-road Transportation: Airplanes Trains Marine Vessels Recreational Vehicles	Off-road Equipment: Construction Agriculture Logging Recreation	Compressed Natural Gas

Figure 2-12 presents 1990-2018 GHG emissions from the three Transportation sub-sectors. Emissions from conventional (gasoline and diesel)-fueled highway vehicles represent approximately 90% of total Transportation sector GHG emissions, with non-highway sources accounting for nearly all the sector's remaining emissions.[46]

[44] North Carolina population data from the North Carolina Office of State Budget and Management, available from https://www.osbm.nc.gov/facts-figures/population-demographics, accessed May 2021.
[45] North Carolina Energy Conservation Code, North Carolina Department of Insurance, recent amendments adopted December 2017 through June 2021, and discussed here: https://www.ncosfm.gov/media/409/open..
[46] Emissions of CO_2 from combustion of biomass fuels by alternative fuel vehicles are not included.

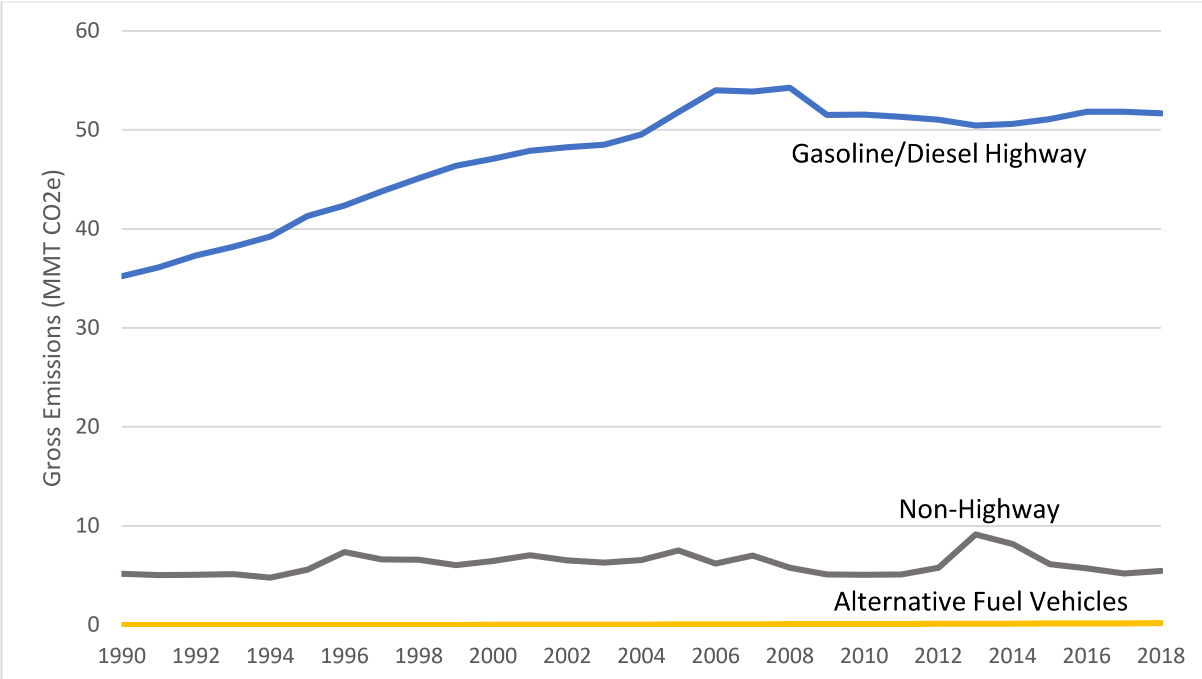

Figure 2-12: Transportation Sector GHG Trends in North Carolina, 1990-2018

Emissions from the Transportation sector are a function of several parameters. The key factors are: (1) population of each vehicle/engine type; (2) VMT/hours of operation; (3) fuel type and consumption; and (4) emissions standards for each fuel/vehicle/engine type. The population of each vehicle type is a function of the number of drivers as well as the type of vehicle/engine registered. Fuel consumption is primarily a function of fuel efficiency and vehicle/engine type. Fuel prices heavily influence the type of vehicle purchased, VMT, and fuel used in a given year. The inventory presented in this document is a “top-down” inventory; therefore, it is difficult to analyze the impact of any one factor on emissions from this sector. The sections below provide high-level conclusions about emissions from the Transportation sector.

As discussed above, Transportation GHG emissions are a function of the use of fuel. This inventory developed onroad mobile GHG emissions from estimates of North Carolina onroad VMT data and EPA’s 3.0.0 version of the MOtor Vehicle Emission Simulator (MOVES3) model. Transportation emissions in the SIT are based on fuel purchases and assumes that the fuel purchased in a state is also consumed in that state. Unlike the VMT-based approach used in DAQ’s onroad mobile source emissions modeling, the SIT’s approach to estimating Transportation sector emissions does not address potential concerns with transportation fuel that is purchased in North Carolina but burned in other states (and vice-versa). Figure 2-13 displays the distribution of 2018 GHG emissions for non-highway sources and individual vehicle category/fuel-type combinations (note that unlike onroad sources, non-highway sources’ emissions are estimated using the SIT). The figure shows that on-road light-duty gasoline vehicles accounted for a large majority of 2018 Transportation sector emissions in North Carolina.

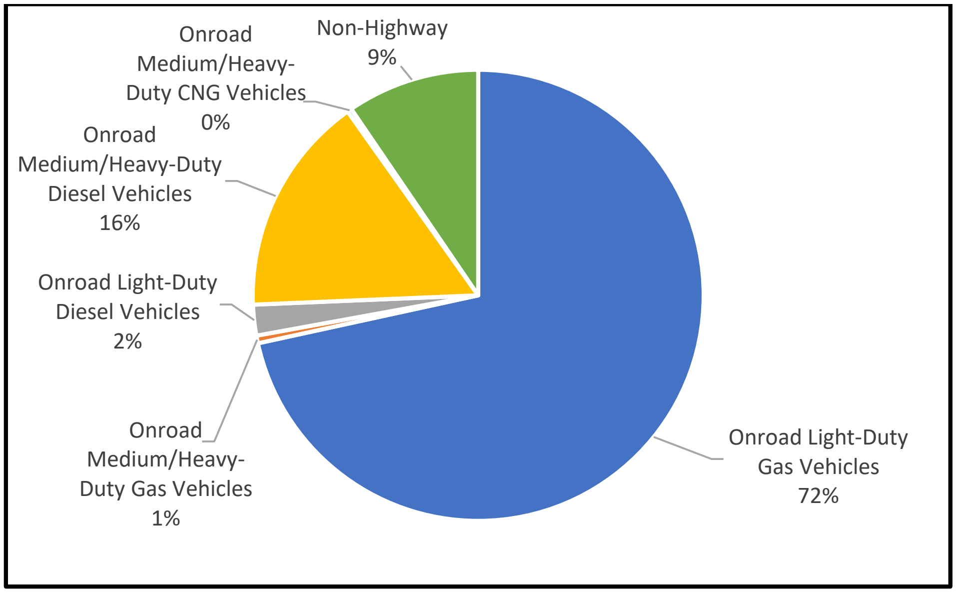

Figure 2-13: Distribution of 2018 North Carolina Transportation GHG Emissions

Table 2-11 presents the historical trend in onroad vehicle category/fuel type emissions in North Carolina's Transportation sector. The changes are due to the impact of VMT changes and the effect of fuel efficiency standards with vehicle turnover.

Table 2-11: Historical Onroad GHG Emissions by Vehicle Type and Fuel in MMT CO_2e

Source Category and Fuel Type	1990	2005	2012	2018	Percent Change in CO_{2e} 2005-2018
Light-Duty Vehicles, Gasoline	29.14	41.38	40.68	41.03	-0.8%
Medium-/Heavy-Duty Vehicles, Gasoline	0.26	0.26	0.28	0.31	22.0%
Light-Duty Vehicles, Diesel	0.88	1.41	1.31	1.26	-10.2%
Medium-/Heavy-Duty Vehicles, Diesel	4.95	8.75	8.74	9.07	3.7%
Medium-/Heavy-Duty Vehicles, Compressed Natural Gas	0.00	0.05	0.12	0.18	234.0%
Grand Total	35.23	51.85	51.13	51.86	0.0%

As shown in Figure 2-14, onroad vehicle GHG emissions generally increased in the State through 2008, reflecting VMT growth stemming from increases in both the driving age population and VMT per driver. Although 2013 VMT generally approximated the level in 2008, significant increases were experienced thereafter. The combination of high fuel prices and the Great Recession contributed to a major decline in VMT between 2008 and 2009 and the slow rate of VMT growth through 2013; similarly, lower fuel prices and the economic recovery resulted in the observed recent VMT increases. Non-highway emissions have remained generally stable over the time frame.

Figure 2-14 demonstrates that North Carolina's VMT trends are generally mirrored at the national level. This figure also shows significant decreases in North Carolina's highway vehicle emissions over the 2008-2013 period, followed by small increases, and then small decreases in the most recent couple of years. In 2018, onroad vehicle GHG levels were about 5% below 2008 peak year values. The fact that onroad vehicle GHG emissions decreased while VMT increased over this period demonstrates the effect of vehicle fuel efficiency improvements. Figure 2-14 suggests that North Carolina incurred a somewhat larger increase in average fuel efficiency than the national average. Additional information would need to be identified to determine the cause(s) for this greater increase in fuel efficiency.

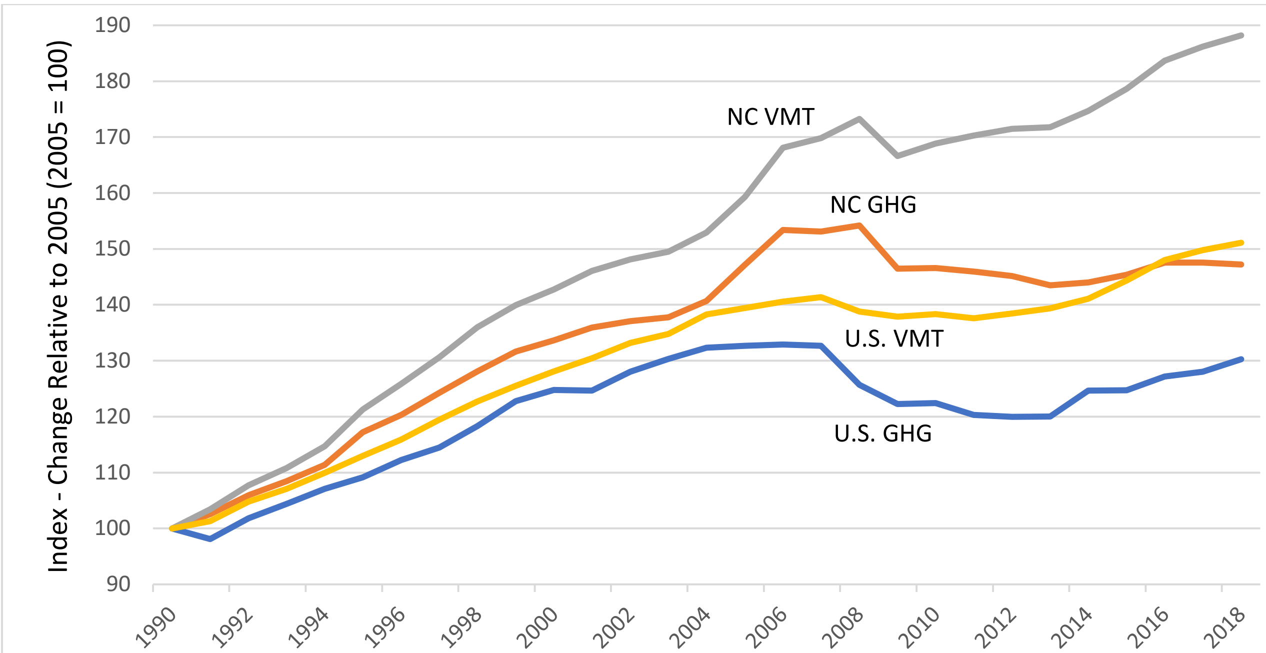

Figure 2-14: Onroad Vehicle GHG and VMT in U.S. and NC, 1990-2018

Figure 2-15 displays North Carolina's and the nation's onroad vehicle emissions on both a per capita and per real GSP basis for 1990-2018. As presented in Figure 2-15, North Carolina's trends are similar to those observed at the national level. The general similarities between the State and national trends are expected given that fuel price trends are generally similar across the country, and because vehicle fuel efficiency policies are generally set at the national level.[47]

[47] See Corporate Average Fuel Efficiency (CAFE) discussion here: https://www.transportation.gov/mission/sustainability/corporate-average-fuel-economy-cafe-standards.

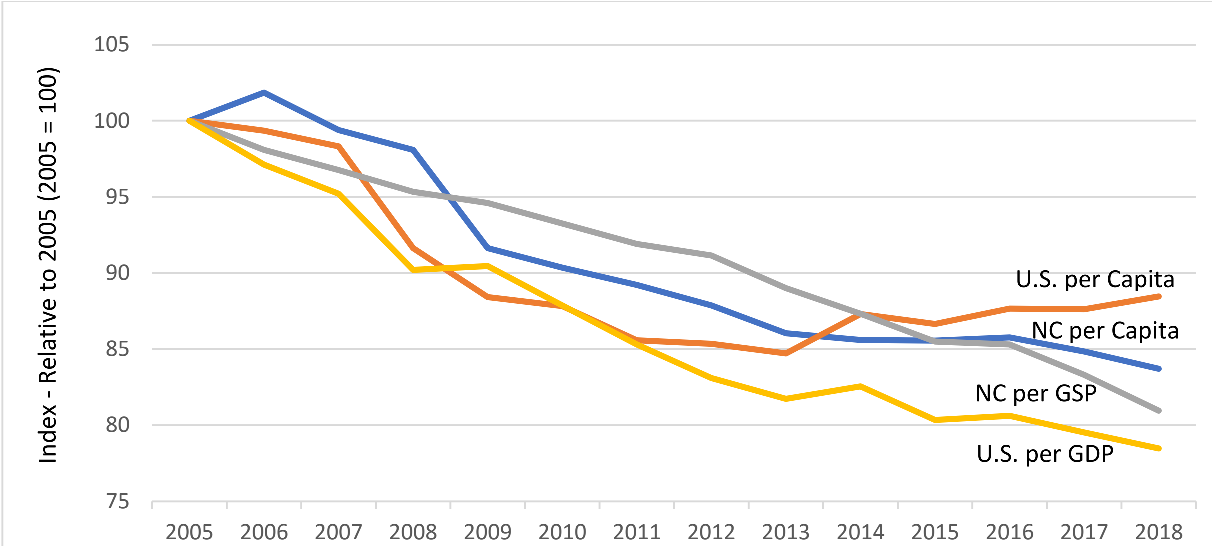

Figure 2-15: Per Capita and Per Real GSP Onroad Vehicle GHG Emissions in U.S. and NC

2.10 Land Use, Land Use Change, and Forestry

The Land Use, Land-Use Change, and Forestry (LULUCF) sector accounts for GHG emissions and/or carbon sinks from the following six source/sink subsectors:

- Carbon flux from forest management;
- Carbon flux from agricultural soil;
- Carbon flux from urban and rural settlements;
- Carbon storage from landfilled yard trimmings and food scraps;
- Fertilization of settlement soils; and
- Forest fires.

Carbon flux refers to the net change in carbon from year to year resulting from activities that emit or store carbon on natural and working lands such as:

- clearing an area of forest to create cropland;
- restocking a logged forest;
- draining a wetland;
- allowing a pasture to revert to grassland; and
- long-term storage of carbon in wood products like lumber.

It is particularly challenging to measure and quantify the mass of carbon associated with various land use activities.[48] Therefore, this sector has a larger amount of uncertainty associated with it compared to other source sectors in the GHG inventory. As federal, state, and non-governmental agencies work to better understand carbon cycles, improve measurement techniques, and develop more robust methods to collect, analyze and model data, there may be additional changes to both the historical and projected emissions, and storage from this sector that may impact the net GHG

[48] See Section 3.1.10 for detailed information on the methodology.

emissions estimates. North Carolina is working with various entities to improve both the methodology and the data sets currently being used to estimate carbon emissions and storage by natural and working lands.

Table 2-12 presents the carbon sinks and GHG emissions for each activity in North Carolina. Each year, North Carolina sequesters about 37 to 43 MMT of CO_2e. The carbon sinks are primarily due to carbon sequestered in above ground biomass and storage of carbon in wood products and landfills. Table 2-12 indicates there has been a 13% increase in the annual carbon sequestered between 2005 and 2018. In 2018, net carbon sinks offset North Carolina's GHG emissions by an estimated 42.1 MMT CO_2e, which is about 26% of the State's gross emissions in that year.

Table 2-12: GHG Emissions and Sinks from LULUCF Sector (MMT CO_2e)

Source/Sink	1990	2005	2012	2015	2018	Percent Change 2005-2018
Forest Carbon Flux*	-43.94	-40.25	-42.03	-42.56	-42.04	4%
Aboveground Biomass	*-26.24*	*-22.65*	*-23.82*	*-24.16*	*-23.75*	
Belowground Biomass	*-5.33*	*-4.55*	*-4.75*	*-4.81*	*-4.72*	
Deadwood	*-0.83*	*-0.75*	*-0.92*	*-0.98*	*-0.97*	
Litter	*-0.15*	*-0.10*	*-0.15*	*-0.17*	*-0.16*	
Soil (Mineral)	*1.30*	*0.90*	*0.56*	*0.46*	*0.45*	
Soil (Organic)	*-0.42*	*-0.15*	*0.00*	*0.05*	*0.07*	
Drained Organic Soil	*0.01*	*0.01*	*0.01*	*0.01*	*0.01*	
Wood products and Landfills	*-12.28*	*-12.96*	*-12.96*	*-12.96*	*-12.96*	
Urea Fertilization	0.01	0.01	0.01	0.01	0.01	
Liming of Soils	0.03	0	0	0	0	
Landfill Yard Trimmings and Food Scraps	-0.64	-0.31	-0.35	-0.33	-0.28	
Agricultural Soil Carbon Flux	1.46	3.02	2.91	1.38	1.76	
Urban Trees	-2.84	-4.58	-5.40	-5.75	-6.11	
Categories not included, CO_2**	3.01	3.59	3.14	3.13	3.11	
Carbon Sinks	**-42.91**	**-38.52**	**-41.72**	**-44.13**	**-43.55**	13%
Forest Fires	*0.43*	*0.88*	*1.20*	*1.05*	*1.05*	
N_2O from Settlement Soils	*0.09*	*0.07*	*0.07*	*0.07*	*0.07*	
Categories not included, CH_4 & N_2O**	*0.22*	*0.28*	*0.30*	*0.30*	*0.30*	
GHG Emissions	**0.74**	**1.23**	**1.57**	**1.42**	**1.42**	16%
Net Carbon Sink	**-42.17**	**-37.29**	**-40.15**	**-42.71**	**-42.13**	13%

* Forest carbon flux is the sum of carbon emitting and carbon sequestering activities listed below in italics, and includes forestland converted to other land categories (including forestland converted to settlements).
**LULUCF categories not included in the SIT (i.e., wetlands remaining wetlands, lands converted to wetlands, grasslands converted to settlements, croplands converted to settlements, other lands converted to settlements, wetlands converted to settlements, and changes in organic soil carbon stocks-settlements remaining settlements).

This annual sequestration of carbon reflects North Carolina's sustainable management of its forests and their economic uses. The State's timber inventory increased by 45% between 1974 and 2013, and the standing tree inventory increased by 1.7% in 2013.[49]

To illustrate the effects of this activity, Table 2-13 presents both the forest acreage and forest carbon stocks on publicly and privately-owned forests in North Carolina. Forest carbon stocks are the net sum of the carbon from the growth and removal of forest biomass. The data show that North Carolina's forested land area increased by 2% while carbon stocks increased by 19% in that same time period. This increase in North Carolina's forest stock results in CO_2 being removed from the atmosphere and being stored in our forest lands.

Table 2-13: Net Forest Carbon Stocks (MMT carbon) and Forest Area (million acres) from 1990 to 2018

Forest Stocks and Area[50]	1990	1995	2000	2005	2010	2015	2017	2018	Percent Change 1990-2018
Aboveground Biomass	351	388	422	455	487	521	534	541	
Belowground Biomass	67	75	82	88	95	102	104	106	
Dead Wood	39	40	41	42	44	45	45	46	
Litter	65	65	65	66	66	66	66	66	
Soil (Mineral)	605	603	601	600	599	598	598	598	
Soil (Organic)	71	72	72	72	73	73	73	73	
Total Forest Carbon Stocks (MMT Carbon)	**1,198**	**1,243**	**1,283**	**1,323**	**1,364**	**1,405**	**1,420**	**1,430**	**19%**
Total Forest Area (Million Acres)	18.51	18.58	18.64	18.71	18.78	18.84	18.87	18.87	**2%**

As stated earlier, this inventory report assumes that beyond 2018, net carbon sinks remain constant. This is a conservative estimate, as there is a large potential for increased carbon sequestration by natural and working lands. A 2018 study by an expert panel looking specifically at North Carolina's ability to sequester carbon in natural and working lands estimated that North Carolina could sequester an additional 10 to 20 MMT CO_2e through various measures such as reforestation and avoided land conversions.[51]

2.11 Projections of GHG Emissions to 2030

This section describes the anticipated post-2018 GHG projected baseline emissions by sector. Figure 2-16 displays North Carolina's total gross GHG emissions trend beginning in the 2005 baseline year through 2030 across all source sectors. The figure shows a large decrease between

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[49] North Carolina State University College of Natural Resources, "North Carolina's Forests and Forest Products Industry by the Numbers, 2013,", published by the North Carolina Cooperative Extension Service, published April 19, 2016, available from: https://content.ces.ncsu.edu/north-carolinas-forest-and-forest-products-industry-by-the-numbers.
[50] Appendix 1. National Scale Estimates for Individual States, 1990-2018, https://www.nrs.fs.fed.us/pubs/59852.
[51] State Natural & Working Lands Initiative: North Carolina Opportunity Assessment, U.S. Climate Alliance, July 2018.

2019 and 2020, which is mostly attributable to a reduction in onroad vehicle emissions due to the Coronavirus (COVID-19) pandemic-related reductions in VMT. Although emission increases are projected through 2024, they are modest. As indicated by the figure, a continuation of North Carolina's downward trend in historical GHG emissions is projected to continue after 2024. Given these projected reductions, year 2030 gross and net emissions are forecast to be about 26% and 35%, respectively, below those of the 2005 baseline year. Because the current baseline year-by-year projections do not account for recent federal transportation sector GHG emission reduction policy changes, nor effects of SL 2021-165, it is expected that these projections will likely overstate future emission levels.

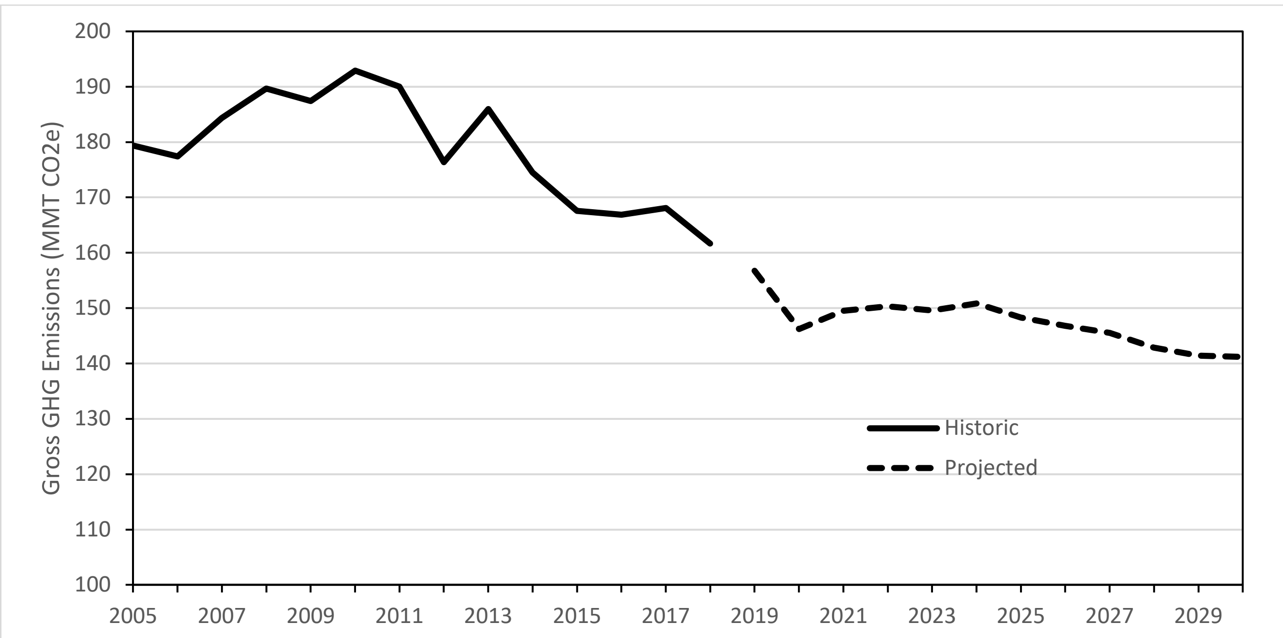

Figure 2-16: Gross GHG Emissions Trends in North Carolina, 2005-2030

Figure 2-17 displays gross GHG emissions trends from 2005 to 2030 by source sector. As indicated by this figure, the Electricity Generation and Use sector shows significant decreases over this timeframe. Although most other sectors show relatively stable emission levels, including the Transportation sector, there are relatively large increases over this period in the Industrial Processes sector. The following sections discuss the projected trends for these three sectors.

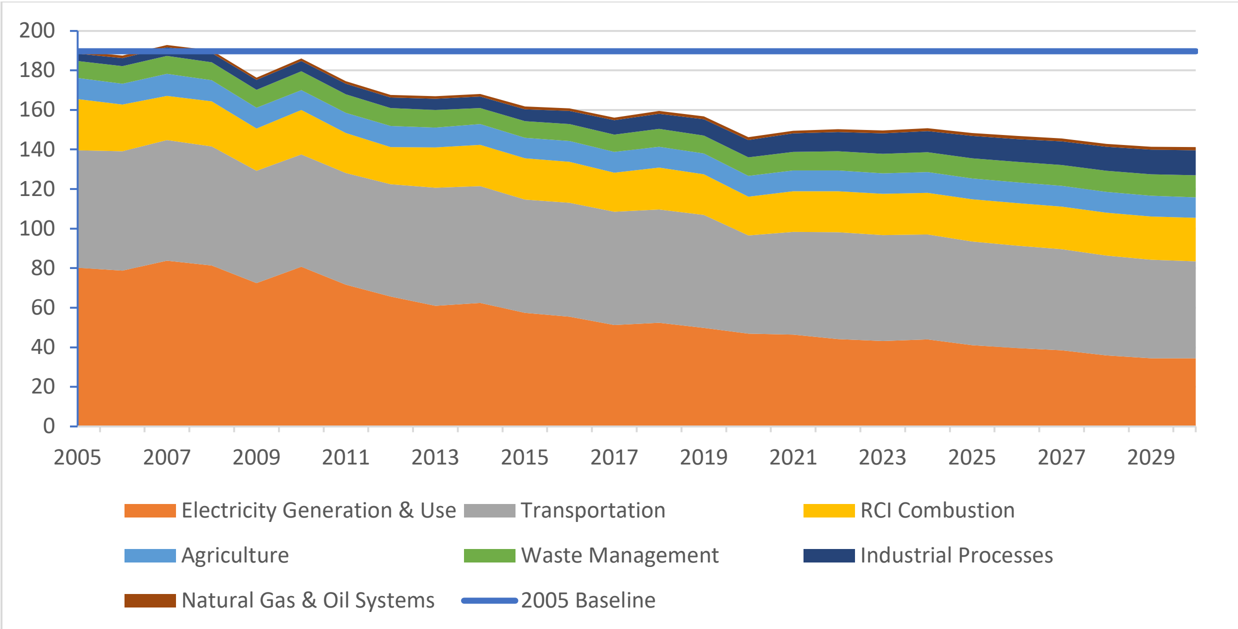

Figure 2-17: Gross GHG Emissions Trends by Source Sector, 2005-2030

2.11.1 Electricity Generation & Use Projections

The baseline forecast for in-state electricity generation includes projections obtained from Duke Energy and the application of recent historical average projections for facilities not included in the Duke Energy projections. The projections for Duke Energy are based on the "Base without Carbon Policy" scenario included in the 2020 Integrated Resource Plan that includes a forecast of generation by plant and emission unit from 2020 to 2030.[52] The Duke Energy forecast includes expected operational changes due to the current REPS law and SL 2017-192 (Competitive Energy Solutions for NC).[53] The "Base without Carbon Policy" scenario was used to provide a reference case against which future GHG reduction laws (e.g., SL 2021-165), regulations, or policies could be analyzed.

Because forecast data are not available for the non-Duke Energy electricity generation units in North Carolina, for all future years, these units are assumed to consume their average fuel consumption (in MMBtu) over the last three available years (2017-2019) as calculated from EIA Form 923 data. These units account for about 10% of total generation in the State.

Table 2-14 reports 2020-2030 GHG emissions projections by fuel type for select years for the Electricity Generation & Use sector (2005 baseline year and 2018 emissions are also shown for comparison). The projection for 2020 incorporates a new 560 MW NGCC plant that came online at

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[52] Duke Energy, "2020 IRP NCDAQ Data - No CO2.xlsx," e-mail transmittal from Cynthia Winston to Ming Xie, NC Division of Air Quality, September 13, 2020. It should be noted that this projection was provided before the proposed Atlantic Coast Pipeline was canceled. Therefore, the projection may be particularly uncertain with respect to natural gas generation resources.

[53] House Bill 589, Session Law 2017-192 (An Act to Reform North Carolina's Approach to Integration of Renewable Electricity Generation Through Amendment of Laws Related to Energy Policy and to Enact the Distributed Resources Access Act), North Carolina General Assembly, 2017, https://www.ncleg.net/gascripts/BillLookUp/BillLookUp.pl?Session=2017&BillID=h589&submitButton=Go.

Duke Energy's Asheville facility to replace the existing 375 MW coal plant. Additional coal generation retirement is forecast to occur by 2024, reducing GHG emissions in 2025 by 23% relative to 2018 levels. The final column of this table displays 2030 GHG emission projections reflecting achievement of the 2030 goal to reduce CO_2 emissions by 70% from 2005 levels by the State's electric public utilities subject to SL 2021-165. Emission estimates by fuel type are not displayed in the table for 2030 because the fuel mix that will be used to achieve the 70% target is currently unknown but will be identified in the forthcoming Carbon Plan.

Table 2-14: GHG Emissions Projections for Electricity Generation by Fuel Type (MMT CO_2e)

Fuel Type	2005	2018	2020	2025	2030	2030 with SL 2021-165
Coal	71.57	28.99	27.69	20.17	10.91	
Natural Gas	1.45	18.03	14.53	16.30	18.96	
Fuel Oil	0.24	0.52	0.29	0.29	0.20	
Wood	0.01	0.02	0.04	0.04	0.05	
Total	**73.27**	**47.56**	**42.48**	**36.80**	**30.12**	**23.91**
Reduction Relative to 2018			11%	23%	37%	
Reduction Relative to 2005		35%	42%	50%	59%	67%

Table 2-15 displays the historical 2005 and 2018 heat input values by fuel type, and the projected baseline heat input values by fuel type for 2020, 2025, and 2030.

Table 2-15: Projected Heat Input for Electricity Generation by Fuel Type

Heat Input (thousand MBtu)	2018	2020	2025	2030	Percent Change 2025-2030	Percent Change 2018-2030
Coal	312,335	298,356	246,616	117,600	-52%	-62%
Natural Gas	339,597	273,582	306,985	357,049	16%	5%
Distillate Fuel	6,940	3,023	3,833	2,682	-30%	-61%
Residual Fuel Oil	--	30	30	30	0%	n/a
Wood	11,775	15,871	15,871	15,871	0%	35%
Total Fuel Use	**670,647**	**590,862**	**573,335**	**493,232**	**-14%**	**-26%**

Renewable energy generation is expected to continue to increase as a result of both North Carolina's REPS (discussed in Section 2.6) and SL 2017-192 (Competitive Energy Solutions for NC). This law directs Duke Energy to increase RE generation by 2021 as follows; (1) connect 3,500 MW of existing solar (or procure equivalent if it is not connected) and (2) procure an additional 2,660 MW of RE via annual competitive solicitations. This law may increase RE generation by an estimated 10.7 million MWh in each year, which based on a simplified estimation procedure (using the current GHG emission factor for the electricity grid region that includes North Carolina), would result in an additional 1.7 MMT CO_2e of avoided GHG emissions annually.[54,55] In addition, SL 2021-165 (House Bill 951) requires the NCUC to develop a plan by the end of 2022 to achieve a 70% reduction in CO_2 emissions emitted in the State from electric public utilities from 2005 levels by the year 2030.

2.11.2 Transportation Projections

Because onroad gasoline and diesel vehicles account for approximately 90% of total Transportation sector emissions, the projected emissions trends for these vehicles are key to understanding overall sector trends. Between 2018 and 2030, North Carolina's GHG emissions from onroad vehicles are forecast to decrease by 17% (see Figure 2-18). This projected decline results from the estimated impact of national fuel economy/GHG emissions standards as forecast in EPA's MOVES3 model. The MOVES3 model reflects the estimated impacts of the Safer Affordable Fuel Efficient (SAFE) vehicle rule.[56] Figure 2-18 also shows the atypical decline in Transportation sector emissions in 2020 and 2021 attributable to pandemic-related decreases in onroad vehicle activity. The EPA recently promulgated updates to the GHG emissions standards, which revise the SAFE vehicle rule emissions standards to be more stringent.[57] Also, the National Highway Traffic Safety Administration (NHTSA) has proposed CAFE standards that would increase vehicle fuel efficiency levels beyond the levels required by the SAFE vehicle rule.[58] Given these recent/upcoming federal policy changes, the projected decrease in onroad vehicle GHG emissions will be more pronounced than that shown in Figure 2-18 (EPA estimates that their new GHG emission standards will reduce 2030 national light-duty vehicle fuel consumption by 7% relative to the SAFE vehicle standards).[59]

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[54] Calculated using a capacity factor of 20% based on EIA Table 6-7.B. Capacity Factors for Utility Scale Generators Not Primarily Using Fossil Fuels, January 2013-February 2018, https://www.eia.gov/electricity/monthly/epm_table_grapher.php?t=epmt_6_07_b.
[55] EPA, Clean Air Markets Division, eGRID 2014 v2, February 2017, https://www.epa.gov/energy/emissions-generation-resource-integrated-database-egrid.
[56] EPA and NHTSA, "The Safer Affordable Fuel Efficient (SAFE) Vehicles Rule for Model Years 2021-2026 Passenger Cars and Light Trucks," 85 FR 24174, April 30, 2020.
[57] EPA, "Revised 2023 and Later Model Year Light-Duty Vehicle Greenhouse Gas Emissions Standards, Final Rule," 86 FR 74434, December 20, 2021.
[58] NHTSA, "Corporate Average Fuel Economy Standards for Model Years 2024–2026 Passenger Cars and Light Trucks, Proposed Rule" 86 FR 49602, September 3, 2021.
[59] EPA, "Revised 2023 and Later Model Year Light-Duty Vehicle GHG Emissions Standards: Regulatory Impact Analysis," EPA-420-R-21-028, December 2021.

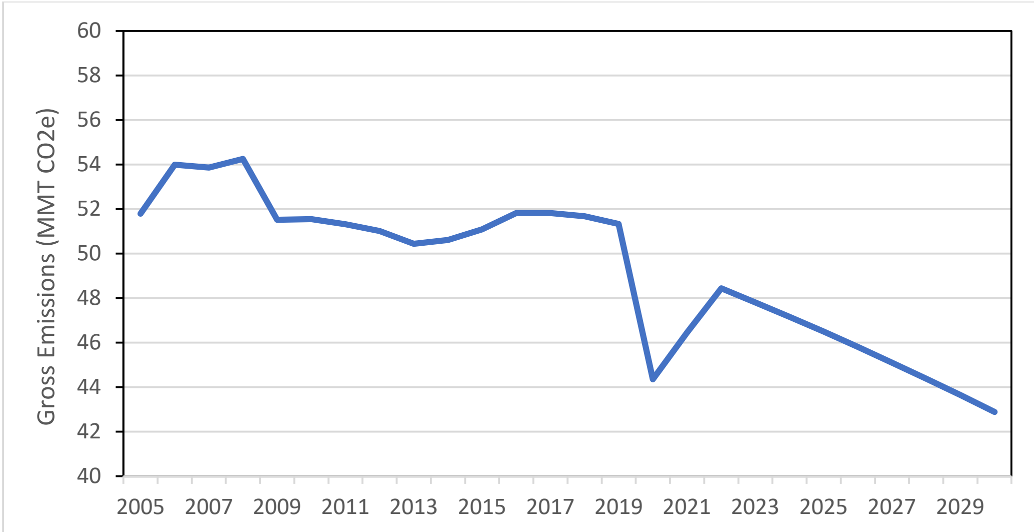

Figure 2-18: Onroad Vehicle Emissions Trends in North Carolina, 2005-2030

2.11.3 Industrial Processes

Contrary to the trends in the sectors discussed previously, GHG emissions from the Industrial Processes sector are projected to increase substantially from 2018 levels (see Figure 2-19). It is important to emphasize, however, that the projections for this sector were not updated for this inventory. In 2018, ODS substitutes accounted for 87% of total Industrial Processes sector emissions in North Carolina. HFCs and PFCs are used as alternatives to classes of ODSs that are being phased-out under the Montreal Protocol.[60] Under sections 601 through 607 of the Clean Air Act, EPA issues regulations that phase-out the production and importation of ODS, consistent with the schedules developed under the Montreal Protocol.[61] Although they provide an effective alternative to ODS refrigerants, HFCs and PFCs are also GHGs. EPA's Projections Tool forecasted a continuation of past historical increases in emissions from North Carolina's ODS substitutes. This forecast reflected a national increase of similar magnitude.[62] When compared to 2017 ODS sector emissions, the Tool projected increases of 62% and 84% in 2025 and 2030 emissions, respectively (these are approximately the same percentage increases projected for the overall Industrial Processes sector). The American Innovation and Manufacturing (AIM) Act, directs EPA to phase down production and consumption of HFCs in the United States by 85% over the next 15 years.[63] The

[60] 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.)
[61] EPA, "What Is the Phaseout of Ozone-Depleting Substances?" accessed from https://www.epa.gov/ods-phaseout/what-phaseout-ozone-depleting-substances, May 2018.
[62] The Tool projects each State's ODS substitute emissions by allocating projected national emissions based on State-level population forecasts.
[63] "Reducing HFCs, AIM Act," background information available from https://www.epa.gov/climate-hfcs-reduction/aim-act, accessed January 2022.

EPA will be implementing the requirements of the AIM Act in a series of regulations, including regulations that have recently been promulgated.[64]

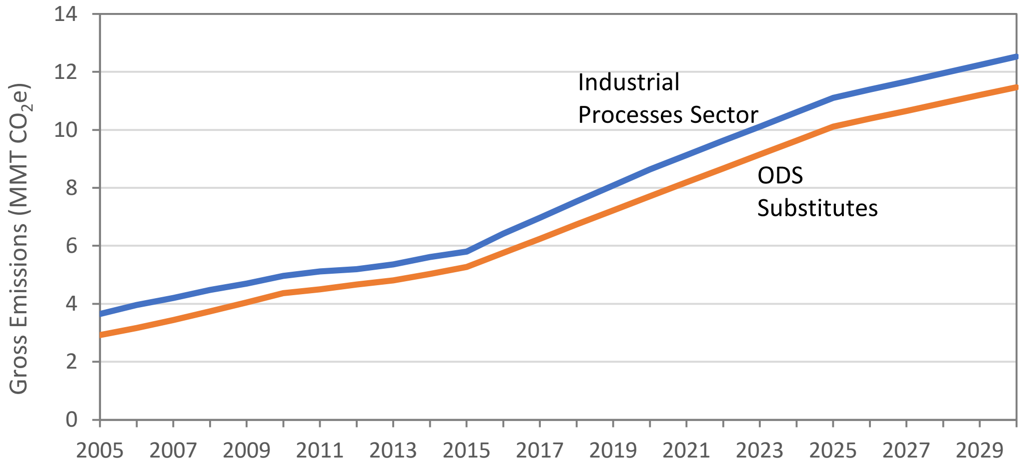

Figure 2-19: Industrial Processes and ODS Substitutes Emissions in North Carolina, 2005-2030

[64] For example, see "Phasedown of Hydrofluorocarbons: Establishing the Allowance Allocation and Trading Program Under the American Innovation and Manufacturing Act, Final Rule," 86 FR 55116, October 5, 2021.

3.0 Methodology

This section explains the methodologies used to develop North Carolina's historical and projected GHG inventory. Section 3.1 discusses the development of historical GHG emissions from 1990 to 2018 while Section 3.2 discusses the development of projected GHG emissions from 2019 to 2030. Data used in developing the inventory comes from a variety of sources as discussed in the subsections below.

This report includes revisions to emission estimates for a subset of the complete list of GHG source categories included in the previous (2019) GHG inventory. These "priority" source categories were the largest contributors to net 2017 emissions in the comprehensive inventory released in 2019. For the following source categories, this updated inventory replaces the previous estimates with estimates based on the most recent information available:

- Electricity Generation and Use;
- Transportation;
- Residential, Commercial, and Industrial (RCI) Fuel Combustion; and
- Land Use, Land Use Change, and Forestry (LULUCF).

For these priority source categories, the DAQ reviewed the latest SIT and other emissions estimation tools, to identify potential emissions estimation refinements relative to the previous inventory. After adopting methodology improvements, the Transportation and LULUCF sectors now have significantly higher emission/sink estimates than the previous inventory.

As demonstrated in Table 3-1, which displays emissions estimates from the previous GHG inventory released in 2019, the first three priority categories represented over 81% of North Carolina's total 2017 gross GHG emissions. The fourth priority source category (LULUCF) is an overall carbon sink that was previously estimated to reduce North Carolina's total gross emissions by nearly 23%. The next largest source category, Agriculture, represented only 7% of North Carolina's estimated 2017 gross emissions. The DAQ is also not aware of any substantive methodology or other changes since the previous inventory that would suggest substantive changes to the previously estimated emission levels. The DAQ currently plans to prepare a revised GHG emissions inventory in 2024.

Table 3-1: Contribution of Priority Source Categories to North Carolina's GHG Emissions in Year 2017 (MMT CO2e)

Source Category	2017 Emissions in NC Inventory (MMT CO_2e)	% of Total Gross Emissions in 2017 NC Inventory
Total Gross Emissions	**150.08**	
Electricity Generating Units	52.60	35.0%
Transportation	48.72	32.5%
RCI Fuel Combustion	20.92	13.9%
Land Use, Land Use Change, and Forestry	-34.03	-22.7%
Total Net Emissions	**116.06**	

3.1 GHG Emissions Using Available Data (1990-2018)

The historical GHG emissions are calculated to show how emissions in North Carolina have changed from 1990 through 2018, the last year of available historical data in the SIT, a spreadsheet-based tool developed by EPA and designed to assist state agencies in preparing state-level GHG inventories and projections.[65] To prioritize resources, the DEQ developed updated 1990-2018 emissions estimates for the following source sectors that account for a large majority of North Carolina's GHG emissions:

- Electricity Generation and Use;
- RCI Fuel Combustion;
- Transportation; and
- Land Use, Land Use Change, and Forestry (LULUCF).

This inventory relies on 1990-2018 emission estimates from the state's previous GHG inventory, which was published in 2019, for the following source sectors:

- Natural Gas and Oil;
- Agriculture;
- Waste Management; and
- Industrial Processes

Combined, these sectors accounted for less than 20% of total state gross emissions in each historical year.

The historical GHG emissions were primarily prepared using the SIT. The SIT simplifies the effort for preparing state-level GHG inventories that is generally consistent with EPA's national inventory. The SIT applies a "top-down" approach to calculate GHG emissions from all relevant anthropogenic source sectors and uses methodologies consistent with those recommended in the 2006 IPCC Guidelines.[66] The use of consistent methodologies ensures that GHG inventories prepared by various entities are comparable.

The SIT is organized into eleven modules for calculating emissions.[67] However, these modules do not correspond to the layout of the sector and source emissions tables presented in Sections 2.0 and 3.0. Instead, they are organized to facilitate the emissions estimation process. Each module has a user's guide that outlines the methodology, and documents the default data sources, emission factors, references, and other pertinent information utilized by the module. There is also a synthesis module which pulls the historical emissions data from each module into a single spreadsheet tool to assist in generating reports and graphics.

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[65] EPA, "State Inventory and Projection Tool," https://www.epa.gov/statelocalenergy/state-inventory-and-projection-tool, accessed September 2021.

[66] 2006 IPCC Guidelines for National Greenhouse Gas Inventories, The National Greenhouse Gas Inventories Programme, The Intergovernmental Panel on Climate Change. Hayama, Kanagawa, Japan, 2006.

[67] North Carolina only utilizes 10 modules since one module estimates emissions from coal production which does not occur in North Carolina.

The SIT includes default data supplied by EPA. The default data are generally publicly available from various federal agencies such as the DOE, the USDA, the FHWA, USGS, U.S. Census Bureau, and EPA. A limited number of source categories utilize data obtained from third party vendors. The default data in the SIT are also frequently used by state and local agencies to develop emission inventories for other air pollutants. For a select number of source categories, the DAQ has replaced the SIT default data with data obtained from North Carolina's state agencies. These data support the development of more accurate emissions estimates for the state. The methodologies, and default and substituted data sources used in each module, are presented in Sections 3.1.1 through 3.1.10.

A detailed discussion of the uncertainty associated with the SIT default data used for the historical GHG emission inventory is outlined in each of the SIT modules, which are available for download from the EPA SIT webpage.[68] As detailed in the individual subsections that follow, the DAQ deviated from SIT defaults for all SIT modules except the CH_4 and N_2O emissions from the stationary source combustion module.

3.1.1 CO_2 Emissions from Fossil Fuel Combustion

Description

The Fossil Fuel Combustion Module calculates CO_2 emissions from combustion of fossil fuels including coal, natural gas, and petroleum products. The sectors included in the module are listed below.[69]

Residential	Industrial	Transportation
Commercial	Electric Power	

It also calculates CO_2 that is stored or released through the use of fossil fuels in the production of solvents, asphalt, synthetic rubber, naphtha, lubricants, and other products.

CH_4 and N_2O emissions from fossil fuel combustion are calculated in two separate modules, the Mobile Combustion Module and the CH_4 and N_2O Stationary Combustion Module. Sections 3.1.2 and 3.1.3 summarize the use of these modules in developing North Carolina's historical GHG emissions estimates.

[68] EPA, "State Inventory and Projection Tool," https://www.epa.gov/statelocalenergy/download-state-inventory-and-projection-tool, accessed September 2021.

[69] The Fossil Fuel Combustion Module estimates emissions from international bunker fuel use. These emissions are from international transportation; therefore, they are not included in state inventories.

Background and Default Data
The methodology for estimating CO_2 emissions from fossil fuel combustion is provided in the User's Guide for this module as well as instructions and information provided in the spreadsheets for each module.[70]

The default historical fuel consumption data provided in the SIT module for North Carolina are used without any adjustments. These default data, which consist of the estimated amount of each type of fuel consumed by each sector in each state, are from the EIA State Energy Data System (SEDS).[71]

Note that the SIT estimates consumption of Industrial sector fuel for non-combustion use for each fossil fuel type.

Deviations from Defaults
Wood, ethanol, and biodiesel are biomass fuels for which CO_2 emissions are excluded from gross GHG emissions. To provide additional transparency, however, the DAQ developed CO_2 emissions estimates for the consumption of these biomass fuels in North Carolina; these estimates are reported in Appendix C.

3.1.2 CO_2 Emissions from Transportation

For the onroad mobile source sector, the DAQ applied the 3.0.0 version of EPA's MOtor Vehicle Emission Simulator (MOVES3) emissions estimation model to estimate emissions for the key years of 2005 and 2018.[72] The MOVES3 model is used in place of the SIT because it is EPA's official onroad mobile source emissions estimation model, it facilitates consistency with all other DAQ onroad mobile source emissions estimation efforts, and it provides emissions forecasting and policy analysis capabilities that are not available from the SIT. Because of the time and resources necessary for performing a MOVES3 run for a given year, it was necessary for the DAQ to limit use of MOVES3 to two historical years: 2005 and 2018. The year 2005 was chosen because it is the baseline year specified by the Paris Agreement, and 2018 was selected for consistency with the final historical year in the SIT.

Because ethanol is a biomass fuel, it was necessary to adjust the CO_2 emissions output from MOVES3 to subtract ethanol-related emissions. The DAQ developed adjustment values for 2005 and 2018 from EIA SEDS transportation sector fuel heat input data to back-out estimated ethanol-related CO_2 emissions. In 2005, ethanol contributed 0.39% of heat input to transportation sector motor gasoline in North Carolina, and this contribution rose to 6.43% in 2018. The DAQ reduced the CO_2 emission estimates from MOVES3 in the two years using these heat input percentages

To estimate pre-2005 onroad mobile source emissions, the DAQ relied on emission trends generated by the SIT's Mobile Combustion Module (see discussion in the following section). Specifically, the DAQ calculated pre-2005 adjustment factors reflecting the SIT's 1990-2005 emission trends, and then

[70] User's Guide for Estimating Direct Carbon Dioxide Emissions from Fossil Fuel Combustion Using the State Inventory Tool, Prepared for State Energy and Environment Program, U.S. Environmental Protections Agency, Prepared by ICF, September 2020. https://www.epa.gov/sites/default/files/2020-10/documents/co2_from_fossil_fuels_users_guid.pdf.
[71] EIA, "State Energy Data System (SEDS): 1960-2018," DOE/EIA-0214(2018), June 2020, accessed from https://www.eia.gov/state/seds/seds-data-complete.php?sid=NC#Consumption.
[72] EPA, "MOVES3: Latest Version of Motor Vehicle Emission Simulator," available from https://www.epa.gov/moves/latest-version-motor-vehicle-emission-simulator-moves, accessed September 2021.

multiplied these factors by the 2005 MOVES3-based emission values. The MOVES3 model was run with output options allowing reporting of results by vehicle regulatory class categories as well as by the default MOVES3 vehicle use categories. The MOVES3 output was also broken down by fuel type. This allowed better alignment of MOVES3 output data with the vehicle and fuel categorizations used in the SIT.

Because a review of the SIT default VMT data, which had originally been compiled by FHWA and EPA, indicated anomalous values for certain years, the DAQ coordinated with the North Carolina Department of Transportation (NC DOT) to develop VMT data that revised the SIT default values. The DAQ's review of the 2005 VMT data identified substantial differences when compared to the 2005 Highway Performance Monitoring System (HPMS) VMT data published by FHWA. Consultation with NC DOT revealed that for years 2008 and earlier, NC DOT used a methodology that tracked VMT on state-maintained roads and locally maintained roads separately, with fewer traffic counts conducted for roadways with lower traffic volume. The NC DOT VMT data for these years was consistently lower than the corresponding FHWA HPMS data. To improve HPMS VMT data quality, the FHWA changed the state VMT reporting requirements in 2009. To meet these new requirements, NC DOT added traffic count stations to cover lower functional class roadways and implemented geographic information system-based processes for tracking VMT. This has led to consistency between the VMT data reported by NC DOT and the HPMS VMT data published by FHWA for 2009 and subsequent years. Based on methods recommended by NC DOT, the 1990-2008 VMT data were adjusted by the DAQ to be consistent with the 2009 and later HPMS data. The 2005 VMT data disaggregated at the county-level were used for GHG emissions modeling with MOVES3. For the 2018 GHG emissions modeling, the DAQ used the county-level VMT data directly as provided by NC DOT. No revisions were warranted since NC DOT VMT tracking and reporting procedures were aligned with FHWA HPMS requirements beginning in 2009.

The DAQ developed 2006-2017 onroad CO_2 emission estimates in three steps. The first step was to develop 2006-2017 VMT estimates for the vehicle/fuel type output by MOVES3. These estimates were calculated from state-level VMT for 2006-2017 and interpolated ratios of each vehicle/fuel type's VMT in that year to the state total VMT. The second step was to develop 2006-2017 CO_2 emission factors for the vehicle/fuel type output by MOVES3. These factors were developed by interpolating between year 2005 and 2018 emission factors that were computed from MOVES3 output for those two years. The final step was to multiply the vehicle/fuel type VMT in each year by the CO_2 emission factors for the vehicle/fuel type in that year.

Future Refinements

Future refinements for biomass emissions estimates will investigate the availability of data for estimating CO_2 emissions from the combustion of landfill and manure gas.

3.1.3 CH_4 and N_2O Emissions from Mobile Combustion

Description

The CH_4 and N_2O Emissions from Mobile Combustion Module calculates CH_4 and N_2O emissions from the following mobile sources:

Gasoline Highway	Non-Highway
Diesel Highway	Alternative Fuel Vehicles

CO_2 emissions from the Transportation sector are calculated as discussed in Section 3.1.2. The Mobile Combustion Module provides an alternate method for calculating CO_2 emissions for highway vehicles that the DAQ used to extrapolate trends in vehicle CO_2 emissions for historical years not modeled via MOVES3.

Background and Default Data

The methodology for estimating CH_4 and N_2O emissions from mobile combustion is provided in the User's Guide for this module as well as instructions and information provided in the spreadsheets for each module.[73]

For highway/alternative fuel vehicles, CH_4 and N_2O emissions can be calculated in the SIT based on several factors including VMT, fuel type, engine type and control technology type for the population of vehicles on roads in North Carolina. However, as noted below, the DAQ used the MOVES3 model to calculate highway vehicle emissions.

CH_4 and N_2O emissions from non-highway mobile sources (e.g., aviation, marine, locomotives, construction equipment), and other non-highway equipment are derived from fuel consumption estimates. The default historical non-highway mobile source fuel consumption estimates provided in the SIT module for North Carolina were used without any adjustments.

Deviations from Defaults

For consistency with the development of highway vehicle CO_2 emission, the DAQ compiled CH_4 and N_2O estimates from the same 2005 and 2018 MOVES3 runs and extrapolation/interpolation procedures that were used to develop onroad vehicle CO_2 estimates. The VMT data that were used to calculate CH_4 and N_2O emissions were the same data that were used to estimate CO_2 emissions. See the discussion of the development of these VMT data and the extrapolation/interpolation procedures in Section 3.1.1.

Future Refinements

The current SIT notes that non-highway international bunker fuel should be removed from the estimates incorporated in the SIT. The DAQ has not identified a reliable method for performing such adjustments. Further research should be conducted to develop an approach for refining these fuel consumption estimates to remove fuels sold in NC but consumed in other countries. Similarly, fuels sold in North Carolina, but burned in other states' airspace should also be removed. However, such an adjustment should also include a counter-balancing method of adding aviation fuels sold in other states but burned in North Carolina's airspace.

[73] User's Guide for Estimating Methane and Nitrous Oxide Emissions from Mobile Combustion Using the State Inventory Tool, Prepared for State Energy and Environment Program, US. Environmental Protections Agency, Prepared by ICF, September 2020. https://www.epa.gov/sites/default/files/2020-10/documents/mobile_combustion_users_guide.pdf.

In addition, the DAQ identified suspect trends in the SEDS transportation sector jet fuel consumption data that are used to estimate aviation emissions. The current SIT incorporates SEDS data that were available at the time of the SIT's release. However, a newer SEDS was recently released. A review of these newer SEDS data indicates that, beginning with year 2010, the EIA has adopted a substantially different methodology for estimating jet fuel sales. This new method does not rely on EIA surveys of fuel suppliers, but rather airport-specific ton-miles data and jet fuel sales data for about 75-90 airports (applying fuel sales per ton-mile data to other airports). The new method increases jet fuel consumption estimates in NC by a large amount as shown in the table below. The table also shows some examples of the large swings in jet fuel consumption in the 2020 SEDS data that are incorporated into the SIT (note that the current SEDS shows similar swings in jet fuel sales in pre-2010 years and a huge increase between 2009 and 2010 owning to the change in consumption estimation methods). The DAQ has used the current SIT's SEDS estimates in developing this inventory update. Further research should be conducted to determine the level of confidence with the new methodology for NC airports before incorporating the new fuel consumption values. In addition, additional consideration should be made as to how to develop pre-2010 fuel consumption values in a more consistent manner than the current SEDS provides.

2010-2018 Jet Fuel Consumption in NC (trillion Btu)

Year	2020 SEDS	2021 SEDS
2010	9.2	64.5
2011	10.2	64.9
2012	22.2	67.4
2013	57.4	73.1
2014	48.9	76.0
2015	20.5	76.6
2016	14.9	80.4
2017	15.3	84.8
2018	18.4	85.4

3.1.4 CH_4 and N_2O Emissions from Stationary Combustion

Description

The CH_4 and N_2O Emissions from Stationary Combustion Module calculates CH_4 and N_2O emissions at stationary sources combusting (1) fossil fuels including coal, natural gas, and petroleum products, and (2) biofuels. The source sectors included in the module are listed below.

Residential	Industrial
Commercial	Electric Power

It also calculates CH_4 and N_2O that are stored or released through the use of fossil fuels in the production of solvents, asphalt, synthetic rubber, naphtha, lubricants, and other products. Stationary Combustion CO_2 emissions are calculated in the Fossil Fuel Combustion Module as discussed in Section 3.1.1.

Background and Default Data

The methodology for estimating CH_4 and N_2O emissions from fossil fuel and biofuel stationary sources is provided in the User's Guide for this module as well as instructions and information provided in the spreadsheets for each module.[74]

The default historical fuel consumption data provided in the SIT module for NC are used without any adjustments. These default data are from the EIA's SEDS.[75] It consists of the estimated amount of each type of fuel consumed by each sector.

Note that for the Industrial sector, the SIT also estimates consumption of fuel for non-combustion use for each fossil fuel type.

Deviations from Defaults

No data or estimation methods outside of those provided by the SIT are utilized in calculations.

Future Refinements

No future refinements have been identified at this time.

3.1.5 Natural Gas and Oil

Description

The Natural Gas and Oil Module calculates CH_4 (and their CO_2-equivalent) emissions from Natural Gas and Oil systems. The subsectors included in the module are listed below.

Natural Gas Production	Natural Gas Distribution
Natural Gas Transmission	Petroleum Production, Refining, and Transportation

GHG emissions from the combustion of natural gas and oil are calculated in the Fossil Fuel Combustion Module as discussed in Section 3.1.1.

Background and Defaults

The methodology for estimating GHG emissions from Natural Gas and Oil systems is summarized in the User's Guide for the module, as well as information provided in the module's spreadsheets.[76] Default activity data are generally not provided in the Natural Gas and Oil Module of the SIT. The focus of running this module for NC was the Natural Gas Transmission and Distribution sectors because the State does not produce or refine any oil or natural gas. CH_4 emission factors in the

[74] User's Guide for Estimating Methane and Nitrous Oxide Emissions from Stationary Combustion Using the State Inventory Tool, Prepared for State Energy and Environment Program, US. Environmental Protections Agency, Prepared by ICF, September 2020. https://www.epa.gov/sites/default/files/2020-10/documents/stationary_combustion_users_guide.pdf.

[75] EIA SEDS: 1960-2015, https://www.eia.gov/state/seds/seds-data-complete.php?sid=NC#Consumption.

[76] "User's Guide for Estimating Carbon Dioxide and Methane Emissions from Natural Gas and Oil Systems Using the State Inventory Tool," prepared by ICF for the State Energy and Environment Program and U.S. Environmental Protections Agency, October 2017, available from https://www.epa.gov/sites/production/files/2017-12/documents/natural_gas_and_oil_users_guide.pdf.

module for Natural Gas Transmission and Distribution are taken from a study conducted by the Gas Research Institute and EPA.[77]

Deviations from Defaults

The CH_4 emission factor for natural gas transmission compressor stations was revised from the module's default value of 983.66 metric tons (MT) per compressor station to 500 MT/station. This updated value reflects the approximate median value calculated from CH_4 emissions reported by NC compressor stations to EPA's GHG reporting program for the years 2011-2016. The 2010-2016 natural gas transmission mileage data input to the module was taken from a North Carolina query performed on the webpage of DOT's Pipeline and Hazardous Materials Safety Administration (PHMSA).[78] Natural gas distribution pipeline miles in NC by material and amount of service data for select years (1990-1995, 2000, 2005, 2010, 2013, 2015, 2016) were taken from PHMSA files.[79] Values for other years were estimated via interpolation.

According to the NCUC there were four liquified natural gas (LNG) liquefaction and storage facilities and 16 natural gas compressor stations operating in NC in 2018.[80] Due to a lack of historical data, the NCUC facility/station counts are used for 1990-2015. There were no natural gas venting and flaring operations associated with natural gas production in NC from 1990-2015 based on EIA information.[81]

Future Refinements

The DAQ did not update the emission estimates for this sector. In future revisions to the inventory for this sector, it would be possible to update the CH_4 emission factor for natural gas transmission compressor stations to reflect the latest North Carolina data in EPA's GHG reporting program. In addition, EPA updated the emissions estimation methods for natural gas systems in support of its national GHG inventory. It may be possible to adopt or modify the updated national emissions estimation methodology for use in improving upon the SIT-based approach to estimating North Carolina emissions.

3.1.6 Imported Electricity

Description - Imported Electricity

Imported electricity is the amount of electrical power that North Carolina imports from power plants that are located outside the State via the regional electricity grid system. Note that emissions associated with

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[77] Gas Research Institute and EPA, Methane Emissions from the Natural Gas Industry, EPA-600/R96-080a and GRI-94/0257, June 1996, https://www.epa.gov/sites/production/files/2016-08/documents/1_executiveummary.pdf.

[78] PHMSA, "2010+ Pipeline Miles and Facilities," available from https://www.phmsa.dot.gov/data-and-statistics/pipeline/pipeline-mileage-and-facilities, accessed April 2018.

[79] PHMSA, "Gas Distribution, Gas Gathering, Gas Transmission, Hazardous Liquids, Liquefied Natural Gas (LNG), and Underground Natural Gas Storage (UNGS) Annual Report Data, accessed from https://www.phmsa.dot.gov/data-and-statistics/pipeline/distribution-transmission-gathering-lng-and-liquid-annual-data

[80] Bill Gilmore, North Carolina Utilities Commission, "Natural Gas Facilities in North Carolina," email transmittal to Andy Bollman, NC Division of Air Quality, January 23, 2018.

[81] EIA, "Natural Gas Gross Withdrawals and Production," available from: https://www.eia.gov/dnav/ng/ng_prod_sum_a_EPG0_VGV_mmcf_a.htm, accessed February 2018.

generating imported electricity do not occur in NC. However, the emissions are generated due to the demand for electricity in NC, therefore, these emissions can be considered part of NC's carbon footprint. Since this power is coming from the regional electricity grid, the average emission factors developed by EPA for the regional grid that contains NC were used to estimate GHG emissions due to imported electricity use.

Background and Defaults - Imported Electricity

Because the SIT does not specifically estimate emissions associated with imported electricity, the DAQ developed an approach. In keeping with the use of fuel consumption estimates used elsewhere in the SIT, the DAQ used EIA SEDS data to reflect the amount of electricity imported into NC. The DAQ specifically used NC "net interstate flow" of electricity data from SEDS.[82] The SEDS "net interstate flow" of electricity represents the difference between the sum of electricity sales and transmission losses within a state and the total amount of electricity generated within that state.

The average GHG emission factors developed by EPA for NC's regional power grid (Southeastern Electric Reliability Council - Virginia/Carolina Subregion or SRVC) as part of the EPA's Emissions & Generation Resource Integrated Database (eGRID) are used to calculate emissions from imported electricity.[83] These emission factors are available on a per kilowatt hour of electricity basis. The EPA does not estimate emission factors for every year. If an emission factor is not available for a given year, the value for the first available year was used (e.g., 2004 CO_2 emission factor is used for all pre-2004 years), or an interpolated value was used. The GHG emissions from imported electricity are reported in the inventory under the "Electricity Generation and Use" sector.

Future Refinements – Imported Electricity

No future refinements have been identified at this time.

3.1.7 Agriculture

Description

The Agriculture Module calculates CH_4 and N_2O emissions from agricultural operations. The subsectors included in the module are listed below.

Enteric Fermentation	Rice Cultivation	Agricultural Soils
Manure Management	Agricultural Residue Burning	

Background and Defaults

The methodology for estimating CH_4 and N_2O emissions from the Agriculture sector is described within the User's Guide for this module as well as instructions and information provided in the spreadsheets for

[82] EIA SEDS: 1960-2018 (complete), EIA, data set downloaded from https://www.eia.gov/state/seds/seds-data-complete.php?sid=US#Consumption, accessed April 2021.

[83] EPA, Clean Air Markets Division, eGRID, available from https://www.epa.gov/energy/emissions-generation-resource-integrated-database-egrid, accessed September 2021.

each subsector of the module.[84] The default historical activity data provided in the SIT module for NC were used without adjustments for the agricultural residue burning, agricultural soils – plant residues and legumes; and agricultural soils – plant fertilizer subsectors. Default animal population and crop production data in the module are from the USDA's National Agricultural Statistics Service (NASS). Because there is no rice production in NC, it is not necessary to perform calculations for the rice cultivation subsector. Default fertilizer use data are from the Association of American Plant Food Control Officials and The Fertilizer Institute. It should be noted that the module applies a national adjustment factor to reconcile differences between methodologies for estimating N_2O from agricultural soils between the SIT and EPA's national inventory.

Deviations from Defaults
The default USDA data in the module were revised for the following livestock categories to reflect the most recent set of available livestock inventory estimates: dairy cattle; sheep; goats; broilers; turkeys; and swine. These data are from online queries of USDA datasets (note that USDA compiles these data sets in cooperation with the NC Department of Agriculture and Consumer Services).[85] These livestock data were used to calculate emissions for the following sub-sectors: enteric fermentation, manure management, and agricultural soils, animals & runoff.

Future Refinements
The DAQ did not update the emission estimates for this sector. The agricultural soils – plant residues and legumes subsector does not include default production data for the following crop types: alfalfa, corn for grain, all wheat, barley, sorghum for grain, oats, rye, millet, rice, soybeans, peanuts, dry edible beans, dry edible peas, Austrian winter peas, lentils, wrinkled seed peas, red clover, white clover, birdsfoot trefoil, arrowleaf clover, and crimson clover. Also, the agricultural soils – plant fertilizer subsector does not provide default data for the following organic types of fertilizers: compost, dried blood, dried manure, activated sewage sludge, other sewage sludge, and tankage. Further research can be conducted to determine if it may be possible to supplement the default crop production and fertilizer use data with data for additional types of crops and fertilizers.

3.1.8 Municipal Solid Waste

Description
The Municipal Solid Waste (MSW) module of the SIT calculates CH_4 emissions from landfilling MSW and CO_2 and N_2O from the combustion of MSW. Some landfills have added gas-collection systems to collect and burn landfill gas for electricity production and other energy uses (landfill-gas-to-energy projects or LFGTE). Other landfills flare the landfill gas which converts the CH_4 portion to CO_2.

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[84] "User's Guide for Estimating Methane and Nitrous Oxide Emissions from Agriculture Using the State Inventory Tool," prepared by ICF for the State Energy and Environment Program and U.S. Environmental Protections Agency, October 2017, available from https://www.epa.gov/sites/production/files/2017-12/documents/ag_module_users_guide.pdf.
[85] U.S. Department of Agriculture, "National Agricultural Statistics Service, Quick Stats," North Carolina data obtained March 2018 via online query of data from https://quickstats.nass.usda.gov/.

CO_2 emitted directly from landfills as biogas and CO_2 emitted from CH_4 combustion at the flares are not counted as an anthropogenic GHG emissions in this inventory.

Background and Defaults

There are two subsectors in this module, landfills and combustion, and the emissions calculation methodology is different for each. The methodology for estimating GHG emissions from MSW is provided in the User's Guide for this module as well as instructions and information provided in the spreadsheets for each module.[86]

The default SIT values were used for landfill flaring which comes from EPA's Landfill Methane Outreach Project (LMOP) database.[87] Default population data from the US Census was included for the landfill gas emissions calculation.

The CH_4 emissions from industrial landfills in the SIT were assumed to be 7% of the MSW landfill emissions. No additional information has been found so the default value was used. Default fractions for plastics, synthetic rubber, and synthetic fiber combustion were also used.

Deviations from Defaults

For the landfill sector, total landfill disposal data from 1990 to 2015 were obtained from the North Carolina Division of Waste Management.[88] These data are published in an annual report based on fiscal year, which is from July 1 through June 30 of the following year and contain construction and demolition (C&D) debris. Since the SIT is based on calendar year rather than this fiscal year, the disposal value was apportioned to the two partial calendar years represented by the fiscal year (half of the value is assigned to each year) then the two values from different fiscal years are summed to get the total for a calendar year. The C&D debris has been apportioned in the same manner and subtracted from the disposal value.

Information regarding LFGTE projects was extracted from EPA's LMOP database to estimate landfill gas annual flow and years of use.[89]

Future Refinements

The DAQ did not update the emission estimates for this sector. Further research into landfill flaring, CH_4 emissions from industrial landfills, and factors for the combustion of plastics, synthetic rubber and synthetic fibers would enhance the accuracy of the emission estimations. For consistency with other modules, North Carolina Office of State Budget and Management population data could be used instead of the default population values.

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[86] User's Guide for Estimating Emissions from Municipal Solid Waste Using the State Inventory Tool, Prepared for State Energy and Environment Program, US. Environmental Protections Agency, Prepared by ICF, October 2017. https://www.epa.gov/sites/production/files/2017-12/documents/solid_waste_users_guide.pdf

[87] EPA, Landfill Technical Data, Landfill and Landfill Gas Energy Project Database, Landfill Methane Outreach Program (LMOP), accessed at https://www.epa.gov/lmop/landfill-technical-data.

[88] Solid Waste Management Annual Reports, North Carolina Division of Solid Waste, accessed at https://deq.nc.gov/about/divisions/waste-management/sw/data/annual-reports.

[89] EPA, Landfill Gas Energy Project Data, Landfill and Landfill Gas Energy Project Database, Landfill Methane Outreach Program (LMOP), accessed at https://www.epa.gov/lmop/landfill-gas-energy-project-data.

3.1.9 Wastewater

Description
The Wastewater module of the SIT calculates CH_4 and N_2O emissions from the treatment of Industrial and Municipal Wastewater. The tool is separated into Municipal Wastewater and Industrial Wastewater sections. The Municipal Wastewater section calculates direct N_2O and N_2O from biosolids, and CH_4 emissions. The Industrial section calculates CH_4 emissions from the fruit and vegetable, red meat, poultry, and pulp and paper industries.

Background and Defaults
The calculation methodology in the Wastewater module is complex and varies within the two sections. The methodology for estimating GHG emissions from Wastewater is provided by the User's Guide for this module as well as instructions and information provided on the spreadsheets for each module.[90]

The source for Municipal Wastewater default values for CH_4 emissions is reported as state and local public works agencies. The default data was used for the Municipal Wastewater section of this tool.

The Industrial section of this module provides default data for the red meat industry but not for the poultry, pulp and paper, or fruit and vegetable industries. The default red meat data was obtained from the USDA's National Agriculture Statistics Service.[91]

Deviations from Defaults
No source of wastewater activity data for the fruits and vegetables industry was located.

Wastewater emissions data for the pulp and paper industry are estimated from emissions related data reported to the DAQ's Internet-Based Enterprise Application Management - Emissions Data (IBEAM-ED) module data by permitted pulp and paper facilities. Emissions are estimated for this sector from 2003 to 2016.

Production data needed to calculate wastewater emissions for the poultry sector has been obtained from NC Department of Agriculture and Consumer Services.[92]

Future Refinements
The DAQ did not update the emission estimates for this sector. State-specific red meat production data and fruit and vegetable production data would enhance the emission estimates for this module.

For consistency with other modules, North Carolina Office of State Budget and Management population data could be used instead of the default population values.

3.1.10 Industrial Processes

Description

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[90] User's Guide for Estimating Emissions from Wastewater Using the State Inventory Tool, Prepared for State Energy and Environment Program, US. Environmental Protections Agency, Prepared by ICF, October 2017. https://www.epa.gov/sites/production/files/2017-12/documents/wastewater_users_guide.pdf.
[91] U.S. Department of Agriculture, "National Agricultural Statistics Service, Quick Stats," accessed at https://quickstats.nass.usda.gov/.
[92] Kris Krueger, NC Department of Agriculture and Consumer Services, "Poultry Databases", email transmittal to Tammy Manning, NC Division of Air Quality, January 12, 2018.

The Industrial Processes module of the SIT calculates GHG emissions as follows:

- CO_2 emissions from cement production, lime manufacture, limestone and dolomite use, soda ash manufacture and consumption, iron and steel production, and ammonia manufacture;
- N_2O emissions from nitric acid production and adipic acid production; and
- HFC, PFC and SF_6 from aluminum production, HCFC-22 production, consumption of substitutes for ODS, semiconductor manufacture, electric power transmission and distribution, and magnesium production and processing.

Background and Defaults

The methodology for estimating GHG emissions from Industrial Processes is provided in the User's Guide for this module as well as instructions and information provided in the spreadsheets for each module.[93] The methodology in the Industrial Processes module varies by sector so each sector is discussed separately with specific examples in the SIT's User Guide.

North Carolina does not have the following Industrial Processes operating in the State: cement manufacture; lime manufacture; ammonia production; nitric acid production; adipic acid production; magnesium production; and HCFC-22 production.

Two sectors in this module, (1) consumption of ODS substitutes and (2) semiconductor manufacture, reflect national emissions allocated to each state. For consumption of ODS substitutes, estimates of the national emissions from this sector are distributed to each state based on the state's percentage of national population. National emissions from the semiconductor manufacturing sector are distributed to NC based on the ratio of the monetary value of North Carolina semiconductor shipments to the value of national semiconductor shipments.[94] The results of the SIT module's GHG estimates for semiconductors were compared to the GHG emissions reported by permitted semiconductor manufacturers in NC and the two data sets were identified as comparable.

Deviations from Defaults

Iron and Steel Production is the only sector in the Industrial Processes module where defaults are not used. The default values for this sector are based on national averages and appeared to overestimate emissions in NC. Therefore, production/activity data from the DAQ's IBEAM-ED module data for the three related permitted facilities were combined and converted to metric tons. These values were entered into the SIT for calendar years 2001 to 2015.

Phosphoric acid production is not included in the SIT Industrial Processes module; however, NC emissions data are reported for this process to EPA's GHG Reporting Program. Because NC has one phosphoric acid production facility that reports their CO_2 emissions to EPA, we have added these emissions to the Industrial Process sector for this report. For calendar years 2010 through 2016, phosphoric acid production CO_2 emissions obtained from GHG Reporting Program are reported in this inventory. Calendar year 2002-2009 emissions were estimated using data reported to the DAQ, current carbon weight percent values obtained from the facility, and the calculation

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[93] User's Guide for Estimating Emissions from Industrial Processes Using the State Inventory Tool, Prepared for State Energy and Environment Program, US. Environmental Protections Agency, Prepared by ICF, October 2017. https://www.epa.gov/sites/production/files/2018-03/documents/industrial_processes_users_guide_508.pdf

[94] U.S. Census Bureau Economic Census for Semiconductors (2012), U.S. Census Bureau, Washington, DC., 2012

equation Z-1A in Part 98 Subpart Z of the Federal Mandatory GHG Reporting Rule. No throughput data or weight percent of carbon are readily available for calendar years 1990 through 2001; therefore, the 2002 CO_2 emission value is reported for these years as a best estimate.

Future Refinements
The DAQ did not update the emission estimates for this sector. For the two sectors that use national emissions, consumption of ODS substitutes and Semiconductor Manufacturing, the SIT default population values for North Carolina from 1990 to 2015 were used since these tables are protected and could not be accessed. For consistency with other modules, the North Carolina Office of State Budget and Management's population data could be used for the allocation process instead of the default population values.

The ODS substitutes sector is the largest contributor to PFC, HFC, and SF_6 emissions for North Carolina. A more in-depth review of the calculation methodology for this sector may be warranted since the projected values for this sector reflect a significantly large increase.

3.1.11 Land Use, Land Use Change, and Forestry

Description
The Land Use, Land-Use Change, and Forestry (LULUCF) module calculates emissions and/or sequestration of CO_2, CH_4, and N_2O from the following six source/sink subsectors:

Carbon flux from forest management
Carbon flux from agricultural soil
Carbon flux from urban trees
Carbon storage in landfilled yard trimmings and food scraps
Fertilization of settlement soils
Forest fires

The current (2020 released) version of the SIT no longer includes the estimation of CO_2 emissions from the liming of soils and urea fertilization in the LULUCF module. These subsectors are now included in the Agriculture module, consistent with EPA's National GHG inventory. Because the DAQ is not revising any of the Agriculture sector emissions in this inventory update, we have retained the previous inventory's estimates for liming of soils and urea fertilization and continued to categorize them in the LULUCF sector.

In addition, the SIT's LULUCF module does not estimate emissions/sequestration for several source categories in the sector. In January 2022, EPA released annual state-level emissions/sink estimates for the LULUCF sector for states' review.[95] This release includes EPA estimates of North Carolina emissions/sinks for the source categories missing in the SIT. The DAQ incorporated the EPA estimates for 1990-2018 for these previously missing source categories into this inventory.

[95] EPA, "Update: Draft Inventory of U.S. Emissions and Sinks by State: 1990-2019," email transmitted by EPA's national GHG inventory staff to Andy Bollman, NC DAQ, January 18, 2022.

Background and Defaults

The methodologies for estimating CO_2, CH_4, and N_2O emissions from the LULUCF sector are provided in the User's Guide as well as instructions and information in the spreadsheets of the LULUCF module.[96] The DAQ used the LULUCF module and default inputs to develop estimates for most LULUCF subsectors. The inputs varied considerably from subsector to subsector but included urbanized land area (and percentage of urban area covered by trees), the amount of yard trimmings/food scraps landfilled, and the amount of synthetic fertilizer applied.

Deviations from Defaults

Table 3-2 below summarizes the areas where the DAQ replaced LULUCF module default inputs or compiled inputs for which default data were not available in the module.

Table 3-2: Exceptions to Use of SIT Methods/Data for LULUCF Subsectors

LULUCF Subsector	Approach/Data Source
Forest Fires	SIT with acreage burned data compiled from NC and federal databases (see text for details).
Categories not modeled in the SIT (Wetlands Remaining Wetlands; Land Converted to Wetlands; Changes in Organic Soil Carbon Stocks; Grassland Converted to Settlements; Cropland Converted to Settlements; Wetlands Converted to Settlements; and Other Lands Converted to Settlements)	Incorporated EPA state-level estimates for these categories, which were transmitted in January 2022.

Forest Fires

Default data for forest fires are not included in the SIT Module. The DAQ obtained wildfires and prescribed fire acreage data for NC from the National Interagency Fire Center (NIFC), integrated federal/state forestry management government agency daily situation reports, also known as the "SIT-209," and the North Carolina Forest Service (NCFS). Because these data sources did not provide sufficient data for estimating prescribed fire acreage data before 2002, the DAQ developed growth factors to apply to the 2002 prescribed fire acreage. These growth factors, which were calculated from National Emissions Inventory (NEI) carbon monoxide emission estimates for NC, were used to back-cast the 2002 prescribed fire acreage estimate for each year back through 1990.[97] The NIFC publishes acres burned data for both wildfires and prescribed fires for each state starting with 2002.[98] The SIT-209 reports contain annual acres burned data of both, wildfires and prescribed

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[96] User's Guide for Estimating Emissions and Sinks from Land Use, Land-Use Change, and Forestry Using the State Inventory Tool, Prepared for State Energy and Environment Program, US. Environmental Protections Agency, Prepared by ICF, September 2020. https://www.epa.gov/sites/default/files/2020-10/documents/land-use_change_and_forestry_users_guide.pdf.

[97] EPA, "Pollutant Emissions Summary Files for Earlier NEIs," available from https://www.epa.gov/air-emissions-inventories/pollutant-emissions-summary-files-earlier-neis, accessed February 2021.

[98] Historical year-end fire statistics by state compiled from National Interagency Coordination Center fire records,

fires, by state (and government agency) beginning in 1999.[99] The NCFS compiles NC wildfire acreage burned data starting in 1928, but the NCFS does not have analogous prescribed fire data available for most years over the 1990-2018 time period.[100]

Because of the different year and fire type coverage of each data source, it was necessary to utilize a combination of data sources to compile acreage data for wildfires and prescribed burning from 1990 through 2018. For wildfires, the DAQ generally relied on the interagency "SIT-209" data but removed the State and Private land acreage total from the SIT-209 and replaced these values with the NCFS' State and Private land wildfire acreage estimate. For prescribed fires, the DAQ generally relied on the SIT-209 acreage estimates. Because data were not available from the SIT-209 for every year, the DAQ used other methods/data to estimate values in some (mostly earlier) years. Table 3-3 summarizes the wildfire and prescribed fire acreage data sources for each year.

Table 3-3: Summary of 1990-2018 Fire Acreage Estimates

Year	Wildfire Acres	Prescribed Fire Acres	Wildfire Acreage Data Source	Prescribed Fire Acreage Data Source
1990	34,514	35,035	NCFS Acres Factor Applied to 1999 Acreage	NEI CO-Based Factors applied to 2002 Acreage
1991	32,067	32,893	NCFS Acres Factor Applied to 1999 Acreage	NEI CO-Based Factors applied to 2002 Acreage
1992	31,561	30,711	NCFS Acres Factor Applied to 1999 Acreage	NEI CO-Based Factors applied to 2002 Acreage
1993	33,382	28,529	NCFS Acres Factor Applied to 1999 Acreage	NEI CO-Based Factors applied to 2002 Acreage
1994	35,128	26,387	NCFS Acres Factor Applied to 1999 Acreage	NEI CO-Based Factors applied to 2002 Acreage
1995	28,005	24,205	NCFS Acres Factor Applied to 1999 Acreage	NEI CO-Based Factors applied to 2002 Acreage
1996	20,211	22,023	NCFS Acres Factor Applied to 1999 Acreage	NEI CO-Based Factors applied to 2002 Acreage
1997	21,132	46,187	NCFS Acres Factor Applied to 1999 Acreage	NEI CO-Based Factors applied to 2002 Acreage
1998	19,875	44,046	NCFS Acres Factor Applied to 1999 Acreage	NEI CO-Based Factors applied to 2002 Acreage
1999	36,090	53,178	SIT-209 except state & private lands from NCFS	NEI CO-Based Factors applied to 2002 Acreage
2000	37,290	29,660	SIT-209 except state & private lands from NCFS	NEI CO-Based Factors applied to 2002 Acreage
2001	35,002	47,319	NCFS Acres Factor Applied to 2002 acreage	NEI CO-Based Factors applied to 2002 Acreage
2002	33,902	40,409	SIT-209 except state & private lands from NCFS	SIT-209
2003	32,061	43,987	SIT-209 except state & private lands from NCFS	SIT-209
2004	20,218	95,490	NIFC except state & private lands from NCFS	NIFC
2005	16,508	124,472	SIT-209 except state & private lands from NCFS	SIT-209
2006	25,695	101,432	SIT-209 except state & private lands from NCFS	NIFC

National Interagency Fire Center, accessed at https://www.nifc.gov/fireInfo/fireInfo_statistics.html.
[99] SIT-209 data obtained from FAM-IT Portal: https://famit.nwcg.gov/applications/SIT209/historicalSITdata, accessed February 2021.
[100] NCFS, "Wildfire and Acreage Statistics: 1928- Present," accessed at https://www.ncforestservice.gov/fire_control/wildfire_statistics.htm, accessed October 2021.

Year	Wildfire Acres	Prescribed Fire Acres	Wildfire Acreage Data Source	Prescribed Fire Acreage Data Source
2007	56,812	95,054	SIT-209 except state & private lands from NCFS	SIT-209
2008	102,673	71,725	SIT-209 except state & private lands from NCFS	SIT-209
2009	25,926	156,361	SIT-209 except state & private lands from NCFS	SIT-209
2010	21,796	115,406	SIT-209 except state & private lands from NCFS	SIT-209
2011	145,721	172,839	SIT-209 except state & private lands from NCFS	SIT-209
2012	36,267	156,310	SIT-209 except state & private lands from NCFS	SIT-209
2013	27,267	146,229	SIT-209 except state & private lands from NCFS	SIT-209
2014	15,554	160,924	NIFC except state & private lands from NCFS	NIFC
2015	12,112	157,321	SIT-209 except state & private lands from NCFS	SIT-209
2016	88,644	169,968	SIT-209 except state & private lands from NCFS	SIT-209
2017	46,318	180,662	SIT-209 except state & private lands from NCFS	SIT-209
2018	19,868	148,301	SIT-209 except state & private lands from NCFS	SIT-209

LULUCF Subsectors Missing from SIT

There are a number of LULUCF subsectors that are not modeled in the LULUCF module. These are:

- Wetlands Remaining Wetlands;
- Land Converted to Wetlands;
- Changes in Organic Soil Carbon Stocks;
- Grassland Converted to Settlements;
- Cropland Converted to Settlements;
- Wetlands Converted to Settlements; and
- Other Lands Converted to Settlements.

To provide a comprehensive LULUCF sector inventory, the DAQ incorporated 1990-2018 emission/sink estimates for North Carolina, which were recently estimated by EPA.[101] The DAQ will work with EPA and other entities to refine these estimates in future inventory updates.[102]

<u>Future Refinements</u>

On January 18, 2022, EPA released state-level estimates of emissions/sinks for the LULUCF sector. Because of the limitations associated with this data set and due to the limited time for reviewing the estimates, the DAQ chose to rely on the SIT as the source of most of LULUCF sector estimates as it is relying on for nearly all inventory sectors (except onroad vehicles). However, due to the lack of any estimates from the SIT for a number of LULUCF sector sub-categories, the DAQ incorporated EPA's recently released emission/sink estimates for the missing sub-categories into North Carolina's

[101] EPA, "Update: Draft Inventory of U.S. Emissions and Sinks by State: 1990-2019," email transmitted by EPA's national GHG inventory staff to Andy Bollman, NC DAQ, January 18, 2022.
[102] For example, the DAQ is currently participating in an effort to develop GHG inventory estimates for NC wetlands (as well as NC estimates for a source category not currently estimated in EPA's national inventory - submerged aquatic vegetation). These estimates are expected to be available in 2022.

inventory. Future versions of the LULUCF sector inventory will incorporate emissions/carbon flux estimates reflecting the best information available at that time.

Carbon flux in the forestry pool represents the net annual increase/decrease in the amount of CO_2 pulled from the air and sequestered as carbon in forest pools and harvested wood product pools compared to the GHGs emitted from these pools in a given year. Harvested Wood Products (HWP) is a component of the larger forest carbon pool, with the carbon in trees that are cut for wood products leaving the forest pool and entering the HWP pool. Furthermore, the HWP subsectors "Products in Use" and "Products Disposed in Solid Waste Disposal Sites (hereafter "Landfills") also represent a pool of carbon that moves from the former to the latter.

The current SIT methodology for HWP is based on NC estimates for only three years: 1987, 1992, and 1997. These data are summarized in the table below. The SIT uses the annual average change in carbon storage between 1987 and 1992 to estimate HWP carbon flux between 1990 and 1992, and the 1992-1997 annual change is used to estimate carbon flux for 1992 through 1997. Since there are no post-1997 data available, the SIT holds the carbon flux value at the estimated 1997 level for 1998 through 2018. Note that the data for HWP is assumed to include both subsectors, wood in use and wood in landfills.

Table 3-4: North Carolina Harvested Wood Products Estimates in SIT (MMT of carbon)

Carbon Stored by Year			Average Annual Change (Flux)	
1987	**1992**	**1997**	**1987-1992**	**1992-1997**
126.3	143.1	160.7	3.35	3.53

As part of the update to the LULUCF sector emissions inventory, the DAQ conducted research to identify data for refining the SIT's emissions estimation methods for the HWP subcategory. Research was performed to identify additional data that could support refinements to the SIT estimates, which identified NC Timber Product Output (TPO) data for 16 of the 29 years between 1990 and 2018 from the USFS' Forest Inventory and Analysis National Program-TPO toolkit.[103] A review of the TPO data, shown below, indicates that, at least for the "Products in Use" subcategory, maintaining carbon flux at the estimated 1997 level may not be the best assumption given the 17% decrease in TPO between 1997 and 2018.[104]

Table 3-5: North Carolina Timber Product Output (TPO) by Year (1000 cubic feet)

Year	TPO	Year	TPO
1990	764,172	2005	782,583
1992	799,203	2007	726,743
1995	830,703	2009	583,451
1997	867,854	2011	619,424

[103] See https://www.fia.fs.fed.us/program-features/tpo/.
[104] Note that the 1990-1997 TPO trend is generally in-line with the SIT trend in carbon storage data for the full HWP subcategory.

1999	791,300		2013	654,919
2001	757,504		2015	671,693
2003	775,114		2018	724,423

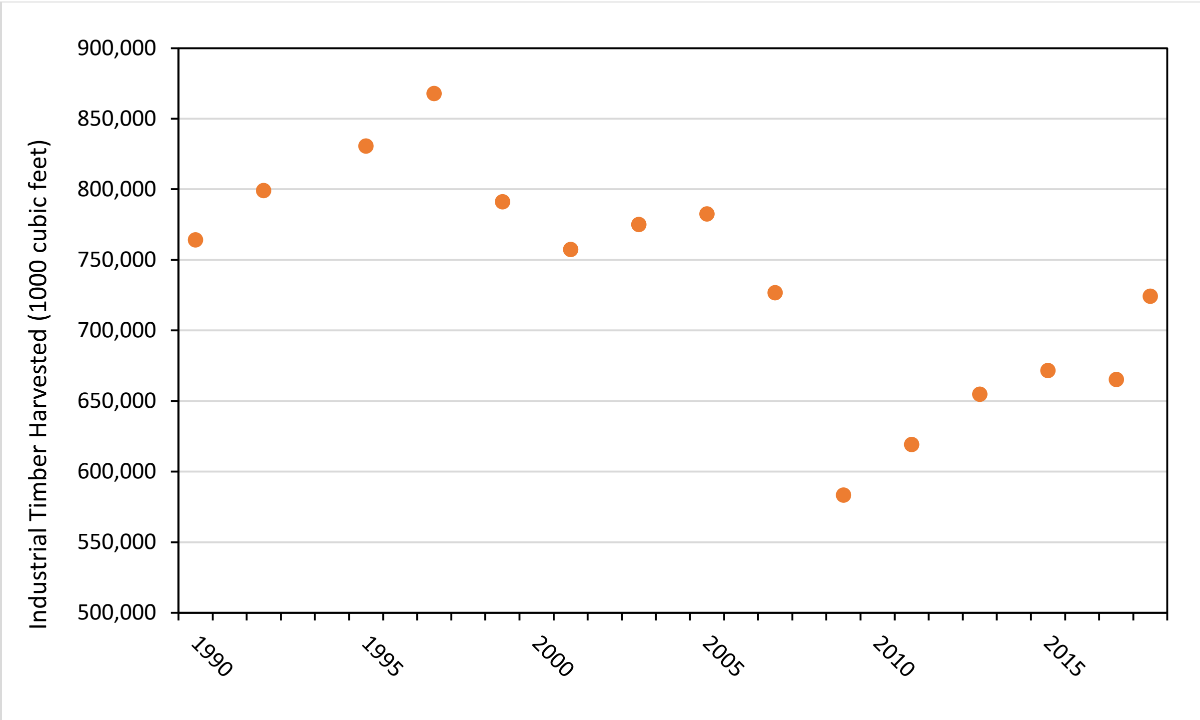

Figure 3-1: North Carolina Timber Product Output, 1990-2018

The DAQ determined that the TPO data should not be used to improve the HWP carbon flux estimates because of the limitations of the data (e.g., the data do not account for changes in carbon flux in wood stored in landfills) and because the EPA and USFS are currently working to develop state-level estimates of carbon flux in HWP. These estimates will be reviewed for potential incorporation into future versions of North Carolina's inventory. In the meantime, the DAQ acknowledges there is a high level of uncertainty associated with the HWP estimates.

3.2 Projected GHG Emissions (2019-2030)

Description

Because of delays in preparing and releasing historical data by various government agencies, 2018 is generally the last year for which historical data are used in estimating North Carolina's GHG emissions. This section summarizes the methods and data sources that are used to project the 2018 emissions from 2019 through 2030. These projections represent a characterization of future emissions based on information available at the time of this study and only reflect the effects of "on-the-books" measures to limit GHG emissions where information is available to characterize their effects.

Background and Defaults

Emissions forecasts are generally developed using the Projections Tool module within EPA's SIT. The Projections Tool has 18 sub-modules for estimating source sector emissions using different default data and forecasting techniques for each sector. The methodologies incorporated into the Projections Tool are summarized in the User's Guide for this module, as well as instructions and information provided in the spreadsheets for each module subsector.[105]

This module forecasts emissions for each source sector using one of the following approaches.

(1) Projections of emissions activity such as fuel use or number of livestock or surrogates for such activity (e.g., human population used to forecast use of ODS substitutes).
(2) Extrapolation of historical trends in emissions or emissions activity.

The following table summarizes the default projection methodology for each source sector.

Table 3-6: Projection Methods for Each Source Sector

Forecast Based on Projections Data	**Forecast Based on Historical Trend**
Electric Generation and Consumption*	Agricultural Soils
RCI Combustion*	Agricultural Residue Burning
Transportation/Mobile Source Combustion	Waste Combustion
ODS Substitutes; Electric Power Systems	Industrial Processes (except subsectors at left)
Solid Waste Management	Wastewater
Livestock	
Natural Gas Systems	

*Excludes wood. Wood consumption is based on the historical trend in fuel consumption.

For sectors that forecast emissions based on projections data, the tool relies on projections of activity data (or surrogate activity data) obtained from similar federal and State resources as those used in calculating historical emissions.

Note that the Projections Tool does not have a sub-module for the LULUCF sector, therefore, the 2018-year estimates for GHG emissions and carbon sinks are carried forward to each forecast year.

Deviations from Defaults

In some cases, different projections methods/data are used to estimate emissions than the default methods/data provided in EPA's Projections Tool. These revisions reflect the use of more current data or North Carolina-specific data than provided by the Tool. The revisions to the Tool defaults are summarized in Table 3-7. In addition to the revisions listed in this table, the Tool default population and GSP projections are replaced with projections from the North Carolina Office of State Budget and Management.[106]

[105] "User's Guide for States Using the Greenhouse Gas Projection Tool," prepared by ICF for the State Energy and Environment Program and U.S. Environmental Protections Agency, October 2020, available for download from https://www.epa.gov/statelocalenergy/download-state-inventory-and-projection-tool.

[106] Carrie Hollis, North Carolina Office of State Budget and Management, "RE: State Projections Data," transmitted to Andy Bollman, NC Division of Air Quality, March 30, 2021.

Table 3-7: Summary of Revisions to EPA Projections Tool Defaults

Sector	Revised Projections Approach(es)	Rationale for Use
Electricity Generation and Imported Electricity	*Electricity Generation* For 2019, heat input (in MMBtu) by fuel type from actual fuel used in 2019, which was obtained from EIA Form 923 data.[107] For 2020 through 2030 heat input, two different data sets are used:	Historical fuel use data are preferable to a projection.
	(a) For Duke Energy facilities: Duke Energy Corporation's September 2020 forecast of North Carolina fuel use (in MMBtu).[108]	Duke Energy's forecast is preferred because it is developed via the Integrated Resource Plan process.
	(b) All other North Carolina electricity generation reflects the average of the last three available years (2017-2019) of fuel consumption (in MMBtu) compiled from EIA Form 923 data.	The historical average fuel use is used since these sources represent a small percentage of sector emissions and forecasts for all these smaller sources are not available.
	Imported Electricity (a) For 2019-2030, SIT projections of retail electricity consumption are used. (b) The percent of imported electricity for all projection years is assumed to be the average of the percent imported for over the last three (2016-2018) available years (10.25%) based on EIA data.[109] (c) The imported electricity use for a given year is calculated as the projected retail electricity consumption multiplied by the percent imported.	Imported electricity emissions were calculated using the 2016-2018 average percent of consumption from net imports. This value was held constant for the projection since there are many uncertainties in estimating imported electricity.
	(d) The EPA's 2019 eGRID GHG emission factor (0.6791lb CO_2e/kWh) and percent grid loss (5.1%) are used to calculate imported electricity GHG emissions.[110]	The 2019 values for the electricity grid emission factors and transmission losses are used for all years of the projection since no other data are available.

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[107] 2017-2019 Form EIA-923 detailed data with previous form data (EIA-906/920), U.S. Energy Information Administration, accessed at https://www.eia.gov/electricity/data/eia923/.

[108] Duke Energy, "2020 IRP NCDAQ Data - No CO2.xlsx," e-mail transmittal from Cynthia Winston to Ming Xie, NC Division of Air Quality, September 13, 2020. It should be noted that this projection was provided before the proposed Atlantic Coast Pipeline was canceled. Therefore, the projection may be particularly uncertain with respect to natural gas generation resources.

[109] EIA SEDS: 1960-2018 consumption data files, accessed at https://www.eia.gov/state/seds/seds-data-complete.php?sid=NC#Consumption.

[110] EPA, Clean Air Markets Division, eGRID 2019, February 2021, https://www.epa.gov/energy/emissions-generation-resource-integrated-database-egrid (specifically, the SRVC subregion output emission rates in Summary Data of eGRID2019: https://www.epa.gov/egrid/summary-data).

Sector	Revised Projections Approach(es)	Rationale for Use
Transportation/Mobile Source Combustion	*Onroad Vehicles* – MOVES3 model run to estimate 2030 emissions. Emissions for 2019-2029 generally estimated as product of VMT and emission factors interpolated from 2018 and 2030 MOVES3 model run output (exceptions are use of actual 2019 and 2020 VMT data, setting 2022 VMT estimates equal to 2019 values, and interpolated 2021 VMT from 2020 and projected 2022 VMT).	More sophisticated modeling approach that uses official EPA onroad mobile source emissions estimation model, provides additional subsector granularity, and future year modeling flexibility.
Industrial Processes	*ODS substitutes* and *Electric Power Transmission & Distribution Systems* – apply growth rates from national projections in Tool to 2015 NC emissions *Aluminum Production* - set emissions to zero in years 2016 thru 2018 (Tool projects zero in all years after 2018) *Phosphoric acid production* is not included in the SIT Industrial Processes module; however, North Carolina emissions data are reported for this process to EPA's GHG Reporting Program. The 2016 CO_2e value is carried forward every year to 2030	Default projections result in some anomalous emissions estimates Aluminum facility has been permanently closed and no longer has air permit Reported GHG emissions from phosphoric acid production are relatively constant from 2002 through 2016, so the 2016 value is held constant for projected years.
Livestock	Replace default emission factors with 2015-year values from Agriculture Module Replace default livestock counts with extrapolated counts developed from State historical trend for each livestock category (count of goats and horses both held constant)	Emission factors outdated in Tool Default projections result in some anomalous estimates
Natural Gas Systems	Extrapolation of 2005-2015 historical emissions	Use of entire 1990-2015 results in suspect 2016 value (inflection point between 2004 and 2005 emissions, so extrapolation starts with 2005)
Agricultural Residue Burning	Apply growth rates by pollutant from national projections to the 2015 emission values for NC	Default projections result in some anomalous emissions estimates
Solid Waste	Apply post-2015 growth rates from the Tool to the 2015 SIT Waste Module emissions values	Projections Tool generates much lower historical emissions estimates than the Waste Module

For the 2030 onroad vehicle GHG emissions modeling, the DAQ used county-level VMT estimates based on travel demand modeling (TDM) projections for 19 counties. TDM results from the latest available Metropolitan Transportation Plan for each of three urban areas were used to develop 2030

VMT estimates. The areas included the Metrolina area (Cabarrus, Cleveland, Gaston, Iredell, Lincoln, Mecklenburg, Rowan, Stanly, and Union counties), the Triad area (Davidson, Forsyth, and Guilford counties), and the Triangle area (Durham, Franklin, Granville, Johnston, Orange, Person, and Wake counties). For the remaining counties, DAQ performed multiple regression analysis using aggregate VMT for the 81 non-TDM counties, total population, driving age (i.e., 16+ years old) population, and real GDP data for North Carolina to identify the variable(s) that best explained historical VMT trends. This analysis determined a strong linear statistical relationship between VMT and total population ($r^2 = 0.93$). The DAQ developed 2030-year non-TDM county VMT projections by multiplying each non-TDM county's 2019 VMT/population by 2030 population forecast for each county's as obtained from the NC Office of State Management and Budget (OSBM) State Demographer's Office.

Estimates of miles traveled for 2030 by light-duty battery electric vehicles (BEVs) were first developed for the Duke Energy service areas of the state (roughly 83 counties) and were then extended to cover the remaining 17 counties serviced by other utilities. Duke Energy provided projected annual light-duty BEV sales and mileage driven within the Duke Energy service areas for the years 2021 through 2035, consistent with their corresponding projections for BEV-related power generation.[111] MOVES3 model input data were developed based on these projections so that the 2030 BEV VMT allocated for the service area counties by the MOVES3 model would closely match the Duke Energy BEV VMT projections for 2030.

To achieve this goal, the MOVES3 default fleet data, which specifies the annual distributions of vehicle types and fuels and is used by the model for VMT allocations, were adjusted to include BEV vehicles based on Duke Energy's BEV sales projections. The BEV sales growth characteristics were retained, but the BEV sales magnitude was scaled to obtain the required MOVES3 BEV VMT allocations. It was assumed that the light-duty BEV population would consist of 75% passenger cars and 25% passenger trucks (i.e., pickup trucks and SUVs).

The adjusted MOVES3 fleet data were then applied for modeling all 100 counties. It was assumed that BEVs would be one-to-one replacements of light-duty internal combustion engine vehicles. This resulted in an estimated statewide 2030 BEV fleet of approximately 318,273 vehicles (257,704 BEV passenger cars, 60,569 BEV light trucks).

Next, the DAQ compiled historical VMT data from the NC DOT for the two years for which it was available (2019 and 2020). To forecast the pace of post-COVID recovery of VMT after 2020, the DAQ compiled national VMT per population projections from the 2021 Annual Energy Outlook (AEO).[112] The DAQ applied the AEO's post-2019 projected change in national VMT/population to the 2019 North Carolina aggregate non-TDM county VMT/population. The DAQ then multiplied the projected VMT/population estimates by OSBM county-level population projections. The resulting VMT projections suggested that by 2022, total North Carolina VMT nearly equaled the last pre-COVID year VMT (i.e., in 2022, projected VMT will be 99.3% of 2019 VMT. As a

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[111] McIntyre, Mark, Duke Energy Corporation, "Base Case IRP assumptions for EVs," transmitted to Andy Bollman, NC DEQ, July 28, 2021.
[112] U.S. Department of Energy, Energy Information Administration, "AEO 2021," February 3, 2021, available from https://www.eia.gov/outlooks/aeo/, accessed November 2021.

conservative assumption, the DAQ set 2022 VMT by vehicle/fuel type values equal to 2019 VMT values. The DAQ developed VMT for 2021 by vehicle/fuel type via interpolation between the 2020 and 2022 VMT. Similarly, the DAQ estimated vehicle/fuel type VMT for 2023-2029 via interpolation between the 2022 and 2030 VMT estimates.

The next step in developing projected onroad emission estimates was to develop 2019-2029 emission factors by vehicle/fuel type for each of the three GHGs by interpolating between the 2018 and 2030 vehicle/fuel type-level emission factors calculated from output of the MOVES3 runs for each year. The last step was to multiply the 2019-2029 VMT projections by vehicle/fuel type developed as described above, and the interpolated 2019-2029 emission factors.

Future Refinements
Additional research may identify improved forecast data/methods for sectors for which projections are based on historical trends. It is also important to keep current with the regulatory landscape and determine when the existing projections no longer reflect current standards. For example, the onroad vehicle emissions projections model the effects of full implementation of vehicle CAFE/GHG emissions standards promulgated by EPA and NHTSA at the time that modeling for this inventory was performed.[113] However, EPA and NHTSA have recently promulgated or proposed revised GHG/fuel efficiency standards for light-duty vehicles.[114] In addition, projections for a few subsectors are based on EPA national forecasts from many years ago (e.g., the projections for Electric Power and Transmission Systems are from a December 2012 report).[115] Future versions of this inventory will utilize the most recent available forecast data at the time that the inventory is prepared. Finally, it is good practice to review the accuracy of these projections as historical data become available, and to incorporate any lessons learned in preparing future GHG forecasts.

Uncertainty
In keeping with our approach of using the SIT for developing historical emissions estimates, the DAQ generally relied on the SIT's Projection Tool to forecast emissions over the 2019-2030 period (major exceptions are use of Duke Energy heat input forecasts for electricity generation and MOVES3-based emissions forecasts for onroad vehicles). In cases where more state-specific and/or recent data were identified than provided in the SIT, the DAQ replaced default values with these more representative data.

There is associated uncertainty with the forecast capability of the SIT and MOVES, use of potentially outdated default data, and inherent uncertainty of GHG policy changes. The DAQ emphasizes our commitment to review the validity of the GHG projections methods used in this effort when undertaking future GHG inventory efforts.

[113] EPA and NHTSA, "The Safer Affordable Fuel Efficient (SAFE) Vehicles Rule for Model Years 2021-2026 Passenger Cars and Light Trucks," 85 FR 24174, April 30, 2020.
[114] EPA, "Revised 2023 and Later Model Year Light-Duty Vehicle Greenhouse Gas Emissions Standards, Final Rule," 86 FR 74434, December 20, 2021, and NHTSA, "Corporate Average Fuel Economy Standards for Model Years 2024–2026 Passenger Cars and Light Trucks, Proposed Rule" 86 FR 49602, September 3, 2021.
[115] EPA, Office of Atmospheric Programs, Climate Change Division, "Global Anthropogenic Non- CO_2 Greenhouse Gas Emissions: 1990 – 2030," EPA 430-R-12-006, revised December 2012.

Appendix A. North Carolina GHG Emissions for All Years

Table A-1: North Carolina Historical GHG Emissions Inventory (1990-1999) in MMT CO_2e

Source Sector	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Electricity Generation and Use	**54.55**	**54.37**	**62.69**	**67.61**	**59.21**	**62.46**	**69.21**	**70.39**	**68.96**	**71.67**
Electric Power Generation	46.28	47.04	54.08	58.67	53.41	56.43	64.27	66.87	66.08	65.42
Imported Electricity [a]	*8.27*	*7.33*	*8.61*	*8.94*	*5.80*	*6.03*	*4.94*	*3.52*	*2.88*	*6.25*
Residential/Commercial/Industrial Combustion[b]	**26.76**	**26.05**	**28.71**	**28.30**	**27.51**	**29.12**	**30.63**	**29.41**	**28.09**	**26.49**
Industrial	17.58	16.94	18.70	17.82	17.03	18.20	18.19	17.89	16.89	15.88
Commercial	3.79	3.60	3.84	4.00	4.36	4.17	4.71	4.50	4.38	4.12
Residential	5.39	5.51	6.17	6.48	6.11	6.74	7.72	7.02	6.81	6.50
Transportation	**40.40**	**41.16**	**42.37**	**43.34**	**44.00**	**46.87**	**49.75**	**50.39**	**51.71**	**52.41**
Gasoline Highway	29.40	30.00	30.82	31.27	31.86	33.39	34.16	35.19	36.35	37.23
Diesel Highway	5.83	6.14	6.49	6.94	7.37	7.91	8.21	8.59	8.77	9.15
Non-Highway	5.17	5.02	5.06	5.13	4.77	5.57	7.37	6.62	6.59	6.03
Alternative Fuel Vehicles	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
Agriculture	**7.06**	**7.67**	**8.13**	**8.75**	**9.86**	**10.44**	**11.28**	**11.26**	**11.28**	**10.59**
Manure Management	2.59	2.94	3.35	3.87	4.68	5.22	5.71	5.79	6.11	5.80
Agricultural Soil Management	2.87	3.03	2.97	3.00	3.18	3.11	3.37	3.29	3.19	2.78
Enteric Fermentation	1.60	1.70	1.81	1.89	2.00	2.11	2.21	2.18	1.98	2.01
Burning of Agricultural Crop Waste	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Waste Management	**6.39**	**6.67**	**6.80**	**7.02**	**7.17**	**7.36**	**7.55**	**7.67**	**7.54**	**7.51**
Municipal Solid Waste	5.47	5.74	5.84	6.02	6.15	6.31	6.48	6.58	6.45	6.39
Wastewater	0.92	0.93	0.96	1.00	1.02	1.05	1.07	1.09	1.09	1.12
Industrial Processes	**1.04**	**1.02**	**1.06**	**1.16**	**1.43**	**1.88**	**2.21**	**2.46**	**2.61**	**2.91**
ODS Substitutes	0.01	0.01	0.05	0.16	0.37	0.85	1.18	1.51	1.72	1.96
Iron & Steel Production	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Electricity Transmission & Distribution	0.77	0.74	0.75	0.75	0.69	0.65	0.59	0.54	0.46	0.47
Semiconductor Manufacturing	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.05	0.06
Soda Ash	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.08	0.07
Limestone and Dolomite Use	0.00	0.00	0.00	0.00	0.01	0.02	0.05	0.01	0.01	0.04
Urea Consumption	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Aluminum Production	0.18	0.18	0.17	0.16	0.14	0.14	0.15	0.15	0.16	0.16
Phosphoric Acid Production	0.00	0.00	0.00	0.00	0.13	0.13	0.13	0.13	0.13	0.13
Natural Gas and Oil Systems	**0.86**	**0.86**	**0.88**	**0.91**	**0.92**	**0.94**	**0.96**	**0.98**	**1.01**	**1.03**
Distribution	0.48	0.48	0.50	0.53	0.54	0.56	0.58	0.60	0.63	0.65
Transmission	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38
Gross Emissions	**137.04**	**137.80**	**150.64**	**157.08**	**150.10**	**159.08**	**171.59**	**172.56**	**171.20**	**172.62**
Net Carbon Sinks – LULUCF [c]	**-42.17**	**-41.93**	**-42.16**	**-43.27**	**-42.10**	**-42.31**	**-40.99**	**-40.95**	**-40.20**	**-39.21**
Forest Fires	0.43	0.40	0.39	0.39	0.38	0.32	0.26	0.42	0.40	0.56
Agricultural Soil Carbon Flux	1.46	1.67	1.42	0.89	1.96	1.27	2.13	1.57	1.85	2.17
N2O from Settlement Soils	0.09	0.09	0.09	0.09	0.09	0.10	0.10	0.10	0.10	0.08
Urea Fertilization	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Liming of Soils	0.03	0.03	0.03	0.02	0.00	0.00	0.00	0.00	0.00	0.00
Landfilled Yard Trimmings and Food Scraps	-0.64	-0.60	-0.60	-0.53	-0.47	-0.39	-0.33	-0.35	-0.35	-0.33
Urban Trees	-2.84	-2.96	-3.07	-3.19	-3.30	-3.42	-3.53	-3.64	-3.76	-3.87
Categories not Elsewhere Included	3.23	3.27	3.29	3.32	3.37	3.40	3.43	3.47	3.52	3.61
Forest Carbon Flux	-43.94	-43.83	-43.71	-44.27	-44.15	-43.61	-43.07	-42.52	-41.98	-41.43
Net Emissions	**94.88**	**95.87**	**108.48**	**113.82**	**108.00**	**116.76**	**130.61**	**131.61**	**131.00**	**133.42**

Notes: Totals may not equal exact sum of subtotals shown in this table due to independent rounding.
[a] Emissions from imported electricity occur outside North Carolina.
[b] Onsite fuel combustion in Residential, Commercial and Industrial Sectors (RCI).
[c] Land Use, Land Use Changes and Forestry (LULUCF).

Table A-2: North Carolina Historical GHG Emissions Inventory (2000-2009) in MMT CO_2e

Source Sector	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Electricity Generation and Use	**75.88**	**74.37**	**76.26**	**72.60**	**77.43**	**80.15**	**78.77**	**83.80**	**81.38**	**72.51**
Electric Power Generation	69.55	66.93	69.40	68.67	69.72	73.27	70.67	76.34	72.69	62.71
Imported Electricity [a]	*6.33*	*7.44*	*6.86*	*3.93*	*7.71*	*6.88*	*8.10*	*7.46*	*8.69*	*9.80*
Residential/Commercial/Industrial [b]	**28.35**	**27.12**	**25.28**	**26.13**	**26.73**	**26.00**	**23.73**	**22.42**	**22.84**	**21.31**
Industrial	16.43	15.65	14.77	13.90	14.16	14.20	13.31	12.53	11.72	10.17
Commercial	4.61	4.55	4.06	4.89	5.31	5.06	4.62	4.19	5.00	5.27
Residential	7.30	6.92	6.46	7.34	7.26	6.75	5.80	5.69	6.11	5.87
Transportation	**53.54**	**54.95**	**54.80**	**54.82**	**56.13**	**59.36**	**60.26**	**60.94**	**60.11**	**56.72**
Gasoline Highway	37.78	38.48	38.72	38.93	39.59	41.64	43.40	43.30	43.60	41.41
Diesel Highway	9.28	9.40	9.53	9.57	9.93	10.16	10.58	10.56	10.64	10.11
Non-Highway	6.46	7.05	6.52	6.28	6.57	7.51	6.21	7.01	5.78	5.12
Alternative Fuel Vehicles	0.01	0.02	0.03	0.04	0.04	0.05	0.07	0.07	0.08	0.09
Agriculture	**10.31**	**10.61**	**10.47**	**10.91**	**10.88**	**10.65**	**10.51**	**11.15**	**10.74**	**10.63**
Manure Management	5.60	6.02	5.98	6.07	5.97	6.02	5.81	6.39	5.94	5.98
Agricultural Soil Management	2.77	2.62	2.52	2.91	3.01	2.74	2.86	2.89	3.01	2.84
Enteric Fermentation	1.94	1.98	1.97	1.94	1.90	1.89	1.84	1.88	1.79	1.81
Burning of Agricultural Crop Waste	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Waste Management	**7.73**	**7.85**	**8.04**	**8.17**	**8.35**	**8.52**	**8.84**	**9.00**	**9.06**	**9.07**
Municipal Solid Waste	6.55	6.67	6.81	6.92	7.04	7.23	7.49	7.65	7.68	7.60
Wastewater	1.18	1.18	1.22	1.26	1.31	1.29	1.35	1.35	1.38	1.47
Industrial Processes	**3.09**	**3.26**	**3.43**	**3.65**	**3.69**	**3.83**	**4.14**	**4.38**	**4.66**	**4.87**
ODS Substitutes	2.21	2.41	2.56	2.67	2.78	2.92	3.17	3.44	3.74	4.05
Iron & Steel Production	0.00	0.04	0.07	0.20	0.10	0.10	0.17	0.17	0.17	0.13
Electricity Transmission & Distribution	0.44	0.42	0.39	0.34	0.32	0.29	0.24	0.22	0.21	0.21
Semiconductor Manufacturing	0.06	0.05	0.07	0.08	0.09	0.09	0.12	0.12	0.11	0.08
Soda Ash	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.07	0.07	0.06
Limestone and Dolomite Use	0.01	0.02	0.02	0.02	0.03	0.03	0.06	0.06	0.04	0.04
Urea Consumption	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Aluminum Production	0.15	0.11	0.12	0.12	0.13	0.13	0.13	0.13	0.13	0.13
Phosphoric Acid Production	0.13	0.13	0.13	0.14	0.16	0.18	0.18	0.18	0.18	0.17
Natural Gas and Oil Systems	**1.05**	**1.07**	**1.10**	**1.12**	**1.15**	**1.17**	**1.19**	**1.20**	**1.22**	**1.24**
Distribution	0.67	0.69	0.72	0.74	0.77	0.79	0.81	0.82	0.84	0.86
Transmission	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38
Gross Emissions	**179.95**	**179.25**	**179.38**	**177.42**	**184.36**	**189.68**	**187.44**	**192.90**	**190.00**	**176.35**
Net Carbon Sinks – LULUCF [c]	**-37.91**	**-37.42**	**-37.21**	**-37.46**	**-37.40**	**-37.29**	**-37.06**	**-37.46**	**-38.00**	**-38.97**
Forest Fires	0.42	0.51	0.46	0.47	0.72	0.88	0.79	0.94	1.09	1.13
Agricultural Soil Carbon Flux	3.17	2.98	3.34	3.08	2.96	3.02	3.48	3.01	2.83	2.39
N2O from Settlement Soils	0.07	0.06	0.06	0.07	0.08	0.07	0.08	0.08	0.07	0.06
Urea Fertilization	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Liming of Soils	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Landfilled Yard Trimmings and Food Scraps	-0.35	-0.35	-0.36	-0.31	-0.31	-0.31	-0.31	-0.30	-0.29	-0.33
Urban Trees	-3.99	-4.11	-4.22	-4.34	-4.46	-4.58	-4.69	-4.81	-4.93	-5.05
Categories not Elsewhere Included	3.64	3.82	3.82	3.85	3.87	3.87	3.80	3.80	3.79	3.75
Forest Carbon Flux	-40.88	-40.34	-40.32	-40.29	-40.27	-40.25	-40.23	-40.21	-40.57	-40.94
Net Emissions	**142.04**	**141.82**	**142.17**	**139.96**	**146.96**	**152.39**	**150.37**	**155.44**	**152.00**	**137.38**

Notes: Totals may not equal exact sum of subtotals shown in this table due to independent rounding.
[a] Emissions from imported electricity occur outside North Carolina.
[b] Onsite fuel combustion in Residential, Commercial and Industrial Sectors (RCI).
[c] Land Use, Land Use Changes and Forestry (LULUCF).

Table A-3: North Carolina Historical GHG Emissions Inventory (2010-2018) in MMT CO_2e

Source Sector	2010	2011	2012	2013	2014	2015	2016	2017	2018
Electricity Generation and Use	**80.72**	**71.64**	**65.61**	**60.96**	**62.47**	**57.36**	**55.42**	**51.29**	**52.32**
Electric Power Generation	71.06	60.71	55.95	54.80	56.23	51.10	50.20	46.64	47.56
Imported Electricity [a]	*9.66*	*10.92*	*9.65*	*6.16*	*6.24*	*6.25*	5.22	4.65	4.76
Residential/Commercial/Industrial[b]	**22.53**	**20.13**	**18.74**	**20.30**	**20.96**	**20.81**	**20.59**	**19.83**	**21.28**
Industrial	10.88	10.49	10.10	10.69	10.25	10.05	10.16	10.18	10.43
Commercial	5.11	4.35	4.17	4.29	4.85	5.31	5.23	5.06	5.22
Residential	6.55	5.29	4.47	5.33	5.86	5.45	5.19	4.60	5.64
Transportation	**56.72**	**56.53**	**56.91**	**59.71**	**58.92**	**57.35**	**57.69**	**57.18**	**57.31**
Gasoline Highway	41.41	41.22	40.96	40.48	40.60	40.96	41.52	41.50	41.34
Diesel Highway	10.13	10.10	10.05	9.95	10.01	10.13	10.30	10.33	10.33
Non-Highway	5.08	5.11	5.78	9.15	8.18	6.12	5.71	5.18	5.46
Alternative Fuel Vehicles	0.10	0.11	0.12	0.12	0.13	0.15	0.16	0.17	0.18
Agriculture	**10.09**	**10.28**	**10.56**	**10.15**	**10.57**	**10.38**	**10.54**	**10.53**	**10.52**
Manure Management	5.72	5.77	5.63	5.55	5.54	5.90	6.05	6.05	6.06
Agricultural Soil Management	2.62	2.78	3.18	2.87	3.30	2.74	2.85	2.84	2.83
Enteric Fermentation	1.74	1.73	1.74	1.72	1.73	1.73	1.64	1.64	1.63
Burning of Agricultural Crop Waste	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Waste Management	**9.51**	**9.35**	**9.09**	**8.85**	**8.05**	**8.44**	**8.60**	**8.77**	**8.94**
Municipal Solid Waste	7.99	7.75	7.52	7.27	6.49	6.82	6.94	7.09	7.23
Wastewater	1.53	1.60	1.57	1.59	1.55	1.61	1.65	1.68	1.71
Industrial Processes	**5.16**	**5.33**	**5.39**	**5.62**	**5.83**	**6.03**	**6.63**	**7.18**	**7.73**
ODS Substitutes	4.36	4.50	4.66	4.81	5.03	5.27	5.76	6.25	6.73
Iron & Steel Production	0.16	0.16	0.15	0.17	0.17	0.15	0.20	0.21	0.22
Electricity Transmission & Distribution	0.21	0.21	0.17	0.16	0.17	0.15	0.20	0.25	0.30
Semiconductor Manufacturing	0.10	0.12	0.11	0.10	0.13	0.13	0.14	0.14	0.15
Soda Ash	0.07	0.07	0.07	0.07	0.07	0.06	0.07	0.07	0.07
Limestone and Dolomite Use	0.05	0.05	0.03	0.05	0.05	0.05	0.06	0.06	0.06
Urea Consumption	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Aluminum Production	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Phosphoric Acid Production	0.20	0.21	0.19	0.25	0.22	0.22	0.20	0.20	0.20
Natural Gas and Oil Systems	**1.25**	**1.26**	**1.28**	**1.29**	**1.31**	**1.32**	**1.34**	**1.35**	**1.37**
Distribution	0.87	0.88	0.90	0.91	0.92	0.94	0.95	0.96	0.97
Transmission	0.38	0.38	0.38	0.38	0.38	0.38	0.39	0.39	0.40
Gross Emissions	**185.98**	**174.52**	**167.56**	**166.88**	**168.11**	**161.68**	**160.80**	**156.13**	**159.48**
Net Carbon Sinks – LULUCF [c]	**-40.27**	**-39.16**	**-40.15**	**-41.89**	**-42.91**	**-42.71**	**-41.39**	**-41.58**	**-42.13**
Forest Fires	0.85	1.98	1.20	1.08	1.10	1.05	1.61	1.41	1.05
Agricultural Soil Carbon Flux	1.89	2.64	2.91	1.75	1.20	1.38	2.09	2.01	1.76
N2O from Settlement Soils	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07
Urea Fertilization	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Liming of Soils	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Landfilled Yard Trimmings and Food Scraps	-0.36	-0.35	-0.35	-0.33	-0.33	-0.33	-0.31	-0.28	-0.28
Urban Trees	-5.16	-5.28	-5.40	-5.52	-5.63	-5.75	-5.87	-5.99	-6.11
Categories not Elsewhere Included	3.73	3.44	3.44	3.44	3.43	3.43	3.41	3.41	3.41
Forest Carbon Flux	-41.30	-41.67	-42.03	-42.39	-42.75	-42.56	-42.39	-42.21	-42.04
Net Emissions	**145.71**	**135.36**	**127.41**	**124.99**	**125.20**	**118.98**	**119.41**	**114.56**	**117.35**

Notes: Totals may not equal exact sum of subtotals shown in this table due to independent rounding.
[a] Emissions from imported electricity occur outside North Carolina.
[b] Onsite fuel combustion in Residential, Commercial and Industrial Sectors (RCI).
[c] Land Use, Land Use Changes and Forestry (LULUCF).

Table A-4: North Carolina Projected GHG Emissions Inventory, (2019-2030) in MMT CO_2e

Source Sector	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Electricity Generation and Use	**49.86**	**46.83**	**46.33**	**44.13**	**43.23**	**43.95**	**41.08**	**39.57**	**38.40**	**35.83**	**34.48**	**34.35**
Electric Power Generation	45.41	42.48	41.92	39.74	38.87	39.63	36.80	35.33	34.19	31.66	30.28	30.12
Imported Electricity [a]	4.45	4.35	4.40	4.39	4.36	4.32	4.28	4.24	4.20	4.17	4.20	4.23
Residential/Commercial/Industrial[b]	**20.56**	**19.65**	**20.55**	**20.74**	**20.75**	**21.10**	**21.38**	**21.53**	**21.64**	**21.74**	**21.84**	**21.96**
Industrial	10.01	9.74	9.97	10.16	10.07	10.37	10.59	10.76	10.87	10.97	11.07	11.18
Commercial	5.35	4.82	5.11	5.15	5.27	5.34	5.42	5.43	5.44	5.46	5.47	5.48
Residential	5.20	5.09	5.48	5.43	5.41	5.39	5.37	5.34	5.33	5.31	5.30	5.30
Transportation	**57.01**	**49.71**	**51.94**	**54.05**	**53.54**	**53.04**	**52.42**	**51.79**	**51.15**	**50.48**	**49.79**	**49.09**
Gasoline Highway	41.01	34.59	36.66	38.62	37.97	37.31	36.64	35.96	35.27	34.56	33.85	33.13
Diesel Highway	10.31	9.76	9.79	9.82	9.84	9.85	9.85	9.85	9.84	9.82	9.79	9.76
Non-Highway	5.49	5.16	5.29	5.41	5.53	5.67	5.72	5.77	5.81	5.86	5.91	5.96
Alternative Fuel Vehicles	0.20	0.20	0.20	0.19	0.20	0.21	0.22	0.22	0.23	0.24	0.24	0.25
Agriculture	**10.52**	**10.51**	**10.50**	**10.50**	**10.49**	**10.48**	**10.47**	**10.47**	**10.46**	**10.45**	**10.45**	**10.44**
Manure Management	6.06	6.06	6.07	6.07	6.08	6.08	6.09	6.09	6.09	6.10	6.10	6.11
Agricultural Soil Management	2.82	2.82	2.81	2.80	2.80	2.79	2.78	2.78	2.77	2.76	2.75	2.75
Enteric Fermentation	1.63	1.63	1.62	1.62	1.61	1.61	1.60	1.60	1.59	1.59	1.59	1.58
Burning of Agricultural Crop Waste	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Waste Management	**9.12**	**9.29**	**9.47**	**9.64**	**9.82**	**10.00**	**10.17**	**10.35**	**10.53**	**10.71**	**10.89**	**11.07**
Municipal Solid Waste	7.38	7.52	7.67	7.81	7.96	8.11	8.26	8.40	8.55	8.70	8.85	9.00
Wastewater	1.74	1.77	1.80	1.83	1.86	1.89	1.92	1.95	1.98	2.01	2.03	2.06
Industrial Processes	**8.29**	**8.84**	**9.33**	**9.83**	**10.32**	**10.81**	**11.31**	**11.59**	**11.88**	**12.16**	**12.45**	**12.73**
ODS Substitutes	7.22	7.71	8.19	8.67	9.15	9.63	10.11	10.38	10.66	10.93	11.20	11.47
Iron & Steel Production	0.23	0.24	0.25	0.26	0.27	0.28	0.28	0.29	0.30	0.31	0.32	0.33
Electricity Transmission & Distribution	0.35	0.40	0.39	0.39	0.39	0.39	0.38	0.38	0.38	0.37	0.37	0.37
Semiconductor Manufacturing	0.15	0.16	0.16	0.17	0.17	0.18	0.18	0.19	0.19	0.20	0.20	0.21
Soda Ash	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.06	0.06	0.06
Limestone and Dolomite Use	0.06	0.06	0.07	0.07	0.07	0.07	0.07	0.08	0.08	0.08	0.08	0.08
Urea Consumption	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Aluminum Production	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Phosphoric Acid Production	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
Natural Gas and Oil Systems	**1.38**	**1.40**	**1.41**	**1.43**	**1.44**	**1.46**	**1.47**	**1.49**	**1.50**	**1.52**	**1.53**	**1.55**
Distribution	0.98	0.99	1.00	1.01	1.02	1.04	1.05	1.06	1.07	1.08	1.09	1.10
Transmission	0.40	0.41	0.41	0.42	0.42	0.42	0.42	0.43	0.43	0.44	0.44	0.45
Gross Emissions	**156.73**	**146.23**	**149.54**	**150.31**	**149.59**	**150.83**	**148.31**	**146.80**	**145.55**	**142.89**	**141.43**	**141.18**
Net Carbon Sinks – LULUCF [c]	**-42.13**	**-42.13**	**-42.13**	**-42.13**	**-42.13**	**-42.13**	**-42.13**	**-42.13**	**-42.13**	**-42.13**	**-42.13**	**-42.13**
Forest Fires	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05
Agricultural Soil Carbon Flux	1.76	1.76	1.76	1.76	1.76	1.76	1.76	1.76	1.76	1.76	1.76	1.76
N2O from Settlement Soils	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07
Urea Fertilization	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Liming of Soils	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Landfilled Yard Trimmings and Food Scraps	-0.28	-0.28	-0.28	-0.28	-0.28	-0.28	-0.28	-0.28	-0.28	-0.28	-0.28	-0.28
Urban Trees	-6.11	-6.11	-6.11	-6.11	-6.11	-6.11	-6.11	-6.11	-6.11	-6.11	-6.11	-6.11
Categories not Elsewhere Included	3.41	3.41	3.41	3.41	3.41	3.41	3.41	3.41	3.41	3.41	3.41	3.41
Forest Carbon Flux	-42.04	-42.04	-42.04	-42.04	-42.04	-42.04	-42.04	-42.04	-42.04	-42.04	-42.04	-42.04
Net Emissions	**114.60**	**104.10**	**107.41**	**108.18**	**107.46**	**108.70**	**106.18**	**104.67**	**103.42**	**100.76**	**99.30**	**99.05**

Notes: Totals may not equal exact sum of subtotals shown in this table due to independent rounding. Electric Power Generation does not incorporate implementation of SL 2021-165.

[a] Emissions from imported electricity occur outside North Carolina.

[b] Onsite fuel combustion in Residential, Commercial and Industrial Sectors (RCI).

[c] Land Use, Land Use Changes and Forestry (LULUCF).

Appendix B. Global Warming Potentials

Each GHG compound has a set of physical properties that determine its ability to increase the temperature of Earth's atmosphere. Two key properties are 1) the ability of a compound to absorb and re-emit energy (radiative efficiency), and 2) how long the compound stays in the atmosphere (atmospheric lifetime). The Global Warming Potential (GWP) is a unitless metric that allows comparisons of the global warming impacts of different GHGs to the warming potential of CO_2. Specifically, GWP is a measure of how much energy the emissions of 1 ton of a gas will absorb relative to the emissions of 1 ton of CO_2 over a given period of time. The larger the GWP, the more that a given gas warms the atmosphere compared to CO_2.

The emissions of each GHG are reported using a common metric called CO_2 equivalent (CO_2e). This approach normalizes the emissions of the various GHGs to reflect the GWP of each compound. For this report the emissions of each GHG are converted to emissions in CO_2e by multiplying the mass of emissions in metric tons by its GWP.

Table B-1 presents the GWPs published by the IPCC's Fourth Assessment Report (AR4) for 20-year and 100-year time horizons. While this inventory uses the 100-year values to calculate GHG emissions as CO_2e, the 20-year value is sometimes used as an alternative. The 20-year values are based on the energy absorbed by a gas over the course of 20 years, which prioritizes gases with shorter lifetimes. Because all GWPs are calculated relative to CO_2, GWPs based on a shorter timeframe will be larger for gases with lifetimes shorter than that of CO_2, and smaller for gases with lifetimes longer than CO_2. In order to comply with international GHG reporting standards under the UNFCCC, and in following EPAs methodology for the Inventory of U.S. Greenhouse Gas Emissions and Sinks, this emissions inventory uses GWP values from AR4 for a 100-year horizon.[116]

[116] Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, 2007, Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor and H.L. Miller (eds.), Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, accessed at https://www.ipcc.ch/publications_and_data/ar4/wg1/en/ch2s2-10-2.html.

Table B-1: Global Warming Potentials Used to Calculate GHG Emissions

	Global Warming Potentials	
Gas	**20 Year**	**100 Year**
CO_2	1	1
CH_4	72	25
N_2O	289	298
HFC-23	12,000	14,800
HFC-32	2,330	675
HFC-125	6,350	3,500
HFC-134a	3,830	1,430
HFC-143a	5,890	4,470
HFC-152a	437	124
HFC-227ea	5,310	3,220
HFC-236fa	8,100	9,810
HFC-4310mee	4,140	1,640
CF_4	5,210	7,390
C_2F_6	8,630	12,200
C_4F_{10}	6,330	8,860
C_6F_{14}	6,600	9,300
SF_6	16,300	22,800
NF_3	12,300	17,200

Appendix C. Treatment of CO_2 Emissions from Biomass Combustion

Biomass in GHG Inventories

Greenhouse gas (GHG) inventories consider emissions from the combustion of biomass differently than emissions from fossil fuel combustion. Under the methodology employed by both the U.S. EPA and the Intergovernmental Panel on Climate Change (IPCC), only emissions of nitrous oxide (N_2O) and methane (CH_4) from biomass combusted for energy are included in the calculation of gross GHG emissions.[117] The carbon dioxide (CO_2) released during this combustion is already included in the inventory through the removal of the biomass fuel in the harvested carbon stocks of the Land Use, Land Use Change, and Forestry (LULUCF) sector. For these reasons, CO_2 emissions from biomass combustion for energy are not included in gross emissions, but rather included in the net emissions reported for the LULUCF sector. However, CO_2 emissions from biomass combusted to produce energy are reported for informational purposes below under the listing "wood and biofuel combustion for energy." North Carolina ethanol consumption values by year were obtained from the SIT, and North Carolina annual wood and biodiesel consumption data were compiled from the EIA's SEDS. The CO_2 emission factors were obtained from EPA's national GHG inventory.[118] As discussed further below, these emissions cannot be included as gross emissions because doing so would result in double-counting of emissions.

Table C-1: North Carolina Wood and Biofuel Combustion CO_2 Emissions in MMT

	Historical					Projected		
	1990	2005	2012	2015	2018	2020	2025	2030
Wood and Biofuel Combustion for Energy[a]	*8.82*	*8.60*	*12.75*	*12.30*	*12.28*	*12.28*	*12.28*	*12.28*

[a]CO_2 emissions from wood and biofuels combustion are not included in energy consumption sector gross emission totals to avoid double-counting. In keeping with IPCC guidelines, these emissions are accounted for through net carbon flux calculations in the Land Use, Land-Use Change, and Forestry sector, while CH_4 and N_2O emissions from biomass combustion are included in gross emissions for each consuming energy sector.

In GHG inventories for the LULUCF sector, the harvest of biomass is tracked along with the growth of existing and new biomass. The year-to-year increase or decrease in the carbon stocks of forests and other land types, the carbon flux, is estimated for this sector. A positive flux indicates carbon is emitted and a negative flux indicates carbon is sequestered. Biomass that is harvested in a given year is separated into 1) biomass that is stored as a product (such as lumber) and 2) biomass that is not stored (such as biomass combusted for energy). The biomass that is not stored is zeroed out of the total harvested carbon stocks and is assumed to be emitted as carbon.

The DAQ is using USFS data and the EPA/IPCC LULUCF sector methodology to calculate carbon flux, which includes biomass harvested in North Carolina for energy combustion. The carbon stock

[117] IPCC Task Force on National Greenhouse Gas Inventories (TFI), Fact Sheet, Q2-10, "According to the IPCC Guidelines CO_2 Emissions from the combustion of biomass are reported as zero in the Energy sector. Do the IPCC Guidelines consider biomass used for energy to be carbon neutral?", https://www.ipcc-nggip.iges.or.jp/faq/faq.html
[118] EPA, "Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2018," EPA 430-R-20-002, Washington, D.C., April 13, 2020, https://www.epa.gov/ghgemissions/inventory-us-greenhouse-gas-emissions-and-sinks-1990-2018.

and flux data obtained from the USFS limits the DAQ's ability to identify the amount of wood removed for combustion or stored in a product.

Trend in Timber Use for Bioenergy Products

The last decade has seen a substantial increase in the production of wood pellets as a fuel. In keeping with EPA procedure, the DAQ assumes that biogenic CO_2 emissions are balanced by CO_2 captured by the regrowth of the trees harvested to produce wood pellets. To ensure transparency, the DAQ commits to reporting available information on the magnitude and potential impacts of the wood pellet industry in North Carolina.

Because wood pellet production data are not available (reflecting producers' confidentiality concerns), the DAQ has compiled relevant North Carolina timber production data for the years for which data are available. As demonstrated by 2011-2018 data, although total roundwood production has increased by about a third during this period, roundwood production for bioenergy/fuelwood has increased by more than a factor of five.[119] Future inventory updates, will attempt to identify better sources of information for characterizing the size and impacts of North Carolina's wood pellet industry.

Table C-2: North Carolina Roundwood Production (million cubic feet)

Year	Total Roundwood Production for Bioenergy/Fuelwood	Total Roundwood Production	Bioenergy/ Fuelwood Production as % of Total Production
2011	15,719	621,777	2.53%
2013	36,863	657,816	5.60%
2015	25,669	673,790	3.81%
2017	51,419	716,862	7.17%
2018	105,532	832,521	12.68%

Biomass in Federal Policies

Separate from GHG inventory methodologies, there are several key programs, policies and studies for the U.S. that determine whether a fuel is carbon neutral for regulatory and other purposes. The various approaches are discussed at a high-level in the following paragraphs.

Congress created the Renewable Fuel Standard (RFS) program to reduce GHG emissions and expand the nation's renewable fuels sector while reducing reliance on imported oil.[120] This program was authorized under the Energy Policy Act of 2005 and expanded under the Energy Independence and Security Act of 2007. The RFS program requires a certain volume of renewable fuel to replace or reduce the quantity of petroleum-based transportation fuel, heating oil or jet fuel.

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[119] Note that production capacity information is available for wood pellet plants in North Carolina. Over the 2011-2018 period, this capacity increased by a factor of 3.9 (data compiled from various public sources, including Security and Exchange Commission 10-K reports), and by another 37% from 2018 to 2020 (based on Energy Information Administration data, see https://www.eia.gov/biofuels/biomass/).

[120] https://www.epa.gov/renewable-fuel-standard-program/overview-renewable-fuel-standard.

EPA determines whether a fuel qualifies as a renewable fuel using a set of requirements. One requirement is that the fuel must achieve a lifecycle reduction in GHG emissions as compared to a 2005 petroleum baseline. Certain fuel feedstocks are grandfathered into the program.

Under EPA's Second Draft Framework for Assessing Biogenic CO_2 Emissions from Stationary Sources, released in November of 2014, CO_2 emissions from biomass combusted at stationary sources cannot be assumed to be carbon neutral.[121] Instead, EPA developed a method for assessing whether the production, processing, and combustion of biomass for energy results in a net contribution of biogenic CO_2 emissions. An important component of the method is the agricultural or forest feedstock carbon and carbon fluxes associated with the landscape where the feedstock is grown and harvested.

In April of 2018, EPA issued a policy statement titled "EPA's Treatment of Biogenic Carbon Dioxide (CO_2) Emissions from Stationary Sources that Use Forest Biomass for Energy Production."[122] EPA's policy in forthcoming regulatory actions will be to treat biogenic CO_2 emissions resulting from the combustion of biomass from managed forests at stationary sources for energy production as carbon neutral. However, EPA also noted that "This statement of agency policy is not a scientific determination and does not revise or amend any scientific determinations that EPA has previously made." EPA's ongoing work under the RFS and Title II will not be impacted by this policy and will continue to be governed by the existing regulatory and statutory process and requirements already in place.

[121] https://yosemite.epa.gov/sab/sabproduct.nsf/0/3235DAC747C16FE985257DA90053F252/$File/Framework-for-Assessing-Biogenic-CO2-Emissions+(Nov+2014).pdf

[122] https://www.epa.gov/sites/production/files/2018-04/documents/biomass_policy_statement_2018_04_23.pdf

Appendix D. 2005 Baseline CO_2 Emissions Associated with Facilities Subject to State Law 2021-165 (House Bill 951)

State Law (SL) 2021-165 applies to Duke Energy Progress (formerly Progress Energy) and Duke Energy Carolinas (formerly Duke Energy) facilities. Table D-1 identifies the facilities owned by Duke Energy or from which Duke Energy purchased power in 2005 and shows 2005 CO_2 emissions based on data from EPA's Emissions & Generation Resource Integrated Database (eGRID).[123] The 2005 CO_2 emissions provided in Table D-1 provide a preliminary estimate of the 2005 baseline for SL 2021-165. The final Carbon Plan approved by the NCUC (due by December 2022) will contain the 2005 CO_2 emissions baseline from which both the 70% CO_2 emissions reduction by 2030 will be calculated and carbon neutrality by the year 2050 will be determined. The baseline for the 2030 target includes the facilities owned/operated by Duke Energy in 2005. The baseline for 2050 target includes the baseline for the 2030 target plus it may also include emissions associated with facilities from which Duke Energy purchased electricity via a power purchase agreement in 2005.

Table D-1: 2005 Baseline CO_2 Emissions for Facilities Affected by SL 2021-165

Owner[1]	Facility Name	Annual CO_2 Emissions (Short Tons), Unadjusted	Annual CO_2 Emissions (Short Tons), Adjusted[2]	Annual CO_2 Emissions (MMT CO_2), Unadjusted	Annual CO_2 Emissions (MMT CO_2), Adjusted[2]
Facilities Owned/Operated by Duke Energy in 2005					
DEC	Belews Creek	14,219,392.54	14,219,392.54	12.90	12.90
DEC	Buck Steam Plant	1,767,345.37	1,767,345.37	1.60	1.60
DEC	Dan River Steam Plant	820,524.02	820,524.02	0.74	0.74
DEC	G. G. Allen	6,224,196.88	6,224,196.88	5.65	5.65
DEC	Cliffside (James E. Rogers Energy Complex)	3,929,891.88	3,929,891.88	3.57	3.57
DEC	Lincoln Combustion Turbine	32,294.70	32,294.70	0.03	0.03
DEC	Marshall	13,331,274.34	13,331,274.34	12.09	12.09
DEC	Riverbend	2,001,257.52	2,001,257.52	1.82	1.82
DEC	Rockingham County Combustion Turbine[3]	40,590.22	40,590.22	0.04	0.04
DEP	Asheville	2,622,902.08	2,622,902.08	2.38	2.38
DEP	Blewett	602.76	602.76	0.00	0.00
DEP	Cape Fear	1,966,487.63	1,966,487.63	1.78	1.78

[123] EPA eGRID 2005 CO_2 Emissions: Data extracted from the "PLNT05" spreadsheet in the Excel workbook file named "eGRID2005_plant" located in the compressed file named "egrid2018_historical_files_since_1996.zip" that can be downloaded from https://www.epa.gov/egrid/download-data.

Owner[1]	Facility Name	Annual CO_2 Emissions (Short Tons), Unadjusted	Annual CO_2 Emissions (Short Tons), Adjusted[2]	Annual CO_2 Emissions (MMT CO_2), Unadjusted	Annual CO_2 Emissions (MMT CO_2), Adjusted[2]
DEP	L. V. Sutton Steam	3,524,531.57	3,524,531.57	3.20	3.20
DEP	H F Lee Steam Electric Plant	2,481,319.10	2,481,319.10	2.25	2.25
DEP	Mayo	5,259,857.10	5,259,857.10	4.77	4.77
DEP	Morehead	331.59	331.59	0.00	0.00
DEP	Roxboro	14,907,671.03	14,907,671.03	13.52	13.52
DEP	Richmond County (Sherwood H Smith Jr Energy Complex)	1,141,585.80	1,141,585.80	1.04	1.04
DEP	W H Weatherspoon	1,012,321.97	1,012,321.97	0.92	0.91
DEP	Wayne County	106,143.34	106,143.34	0.10	0.10
	Subtotal	**75,390,521.42**	**75,390,521.42**	**68.39**	**68.39**
Facilities from which Duke Energy Purchased Electricity via a Power Purchase Agreement in 2005					
DPV	Plant Rowan	249,957.78	249,957.78	0.23	0.23
CPI-USA	Primary Energy Roxboro	246,911.80	212,229.09	0.22	0.19
CPI-USA	Primary Energy Southport	606,913.78	305,008.84	0.55	0.28
	Subtotal	**1,103,783.36**	**767,195.71**	**1.00**	**0.70**
	Totals	**76,494,304.78**	**76,157,717.13**	**69.39**	**69.09**

[1] DEC = Duke Energy Carolinas, DEP = Duke Energy Progress, DPV = Duke Progress Ventures, and CPI = Capital Power Incorporated.

[2] In eGRID, EPA adjusted the heat input and CO_2 emissions for the Primary Energy Roxboro and Southport facilities to remove thermal energy that is used for purposes other than to generate electricity for the grid. In addition, for Primary Energy Roxboro, EPA adjusted CO_2 emissions to remove emissions associated with burning biomass to be consistent with IPCC accounting procedures.

[3] In 2005, DEC purchased power from Rockingham Power, LLC via a power purchase agreement. Subsequently, in 2006, DEC purchased the facility from Rockingham Power, LLC. See Transfer of Certificate of Public Convenience and Necessity and Generating Facility from Rockingham Power, LLC, to Duke Power Company LLC, and Request for Issuance of Certificate of Public Convenience and Necessity Pursuant to G.S. 62-110 to Duke Power Company LLC and G.S. 62-110.1, State Of North Carolina, Utilities Commission Raleigh, Docket No. E-7, Sub 816 And Docket No. Emp-1, Sub 1, Issued July 25, 2006 (https://starw1.ncuc.net/NCUC/ViewFile.aspx?Id=57f8031d-0eb6-4d1b-a442-69b5a58d769a).