

# Chapter 2

## Inventory and Projections of GHG Emissions

### Introduction

This chapter presents a summary of North Carolina’s anthropogenic greenhouse gas (GHG) emissions and sinks (carbon storage) from 1990 to 2020. The Center for Climate Strategies (CCS) prepared a preliminary draft of North Carolina’s GHG emissions and reference case projections under contract to the North Carolina Department of Environment and Natural Resources’ (DENR) Division of Air Quality (DAQ).<sup>1</sup> The preliminary draft inventory and reference case projections, completed in February 2006, provided DENR/DAQ with an initial, comprehensive understanding of current and possible future GHG emissions. The preliminary draft report was provided to the North Carolina Climate Action Plan Advisory Group (CAPAG) (and its Technical Work Groups [TWGs]) to assist the CAPAG in understanding past, current, and possible future GHG emissions in North Carolina and thereby inform the mitigation option development process. The CAPAG and the TWGs also provided comments for improving the reference case projections. Subsequently, the inventory and reference case projection estimates were revised to incorporate revisions approved by the CAPAG. The information presented in this chapter reflects the information presented in the final inventory and reference case projections report (hereafter referred to as the *Inventory and Projections*).<sup>2</sup>

Historical GHG emissions estimates (1990 through 2005)<sup>3</sup> were developed using a set of generally accepted principles and guidelines for state GHG emissions, relying to the extent possible on North Carolina–specific data and inputs. The initial reference case projections (2006–2020) are based on a compilation of various existing North Carolina projections of electricity generation, fuel use, and other GHG-emitting activities, along with a set of simple, transparent assumptions described in the appendixes of the *Inventory and Projections* report.

The *Inventory and Projections* covers the six types of gases included in the U.S. Greenhouse Gas Inventory: carbon dioxide (CO<sub>2</sub>), methane (CH<sub>4</sub>), nitrous oxide (N<sub>2</sub>O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF<sub>6</sub>). Emissions of these GHGs are presented using a common metric, CO<sub>2</sub> equivalence (CO<sub>2</sub>e), which indicates the relative contribution of each gas, per unit mass, to global average radiative forcing on a global warming potential– (GWP–) weighted basis.

It is important to note that the emissions estimates reflect the *GHG emissions associated with the electricity sources used to meet North Carolina’s demands*, corresponding to a consumption-based approach to emissions accounting. Another way to look at electricity emissions is to consider the *GHG emissions produced by electricity generation facilities in the state*. This report

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<sup>1</sup> *Revised Draft North Carolina Greenhouse Gas Inventory and Reference Case Projections, 1990–2020*, prepared by the Center for Climate Strategies for the North Carolina DENR/DAQ, February 2006.

<sup>2</sup> *Final North Carolina Greenhouse Gas Inventory and Reference Case Projections, 1990–2020*, prepared by the Center for Climate Strategies for the North Carolina DENR/DAQ, September 2007.

<sup>3</sup> The last year of available historical data varies by sector, ranging from 2000 to 2004.

covers both methods of accounting for emissions, but for consistency, all total results are reported as *consumption-based*.

## North Carolina Greenhouse Gas Emissions: Sources and Trends

Table 2-1 provides a summary of GHG emissions estimated for North Carolina by sector for the years 1990, 2000, 2005, 2010, and 2020. As shown in this table, North Carolina is estimated to be a net source of GHG emissions, but with sinks of GHG emissions due to the forestry sector. We note that there are significant uncertainties associated with estimating forest carbon sinks. In the sections below, we discuss GHG emission sources (positive, or *gross*, emissions) and sinks (negative emissions) separately in order to identify trends, projections, and uncertainties clearly.

The next section of the report provides a summary of the historical emissions (1990 through 2005) followed by a summary of the forecasted reference case projection year emissions (2006 through 2020), and then by a description of key uncertainties.

**Table 2-1. North Carolina historical and reference case GHG emissions, by sector\***

(Million Metric tons CO <sub>2</sub> e)	1990	2000	2005	2010	2020
<b>Energy</b>	<b>121</b>	<b>160</b>	<b>167</b>	<b>187</b>	<b>218</b>
Electricity Use (Consumption)	53.8	75.4	75.8	85.8	98.4
Transportation Fuel Use	39.7	52.7	59.4	66.4	81.5
Res/Comm/Other Ind. Fuel Use	27.3	30.9	31.8	34.5	38.5
<b>Other</b>	<b>14.8</b>	<b>21.1</b>	<b>25.2</b>	<b>27.7</b>	<b>37.2</b>
Industrial Processes	1.6	3.1	5.4	7.1	15.1
Agriculture	8.3	11.0	13.3	14.1	15.5
Waste Management	4.8	7.0	6.5	6.5	6.6
<b>Gross Emissions (Consumption Basis)</b>	<b>136</b>	<b>180</b>	<b>192</b>	<b>214</b>	<b>256</b>
<i>Change relative to 1990</i>		33%	42%	58%	88%
<i>Change relative to 2000</i>			7%	19%	42%
<b>Forestry</b>	<b>-23.2</b>	<b>-23.7</b>	<b>-23.7</b>	<b>-23.7</b>	<b>-23.7</b>
<b>Net Emissions (Consumption Basis, Including Forest Sink)</b>	<b>112</b>	<b>156</b>	<b>169</b>	<b>191</b>	<b>232</b>
<i>Change relative to 1990</i>		39%	50%	70%	106%
<i>Change relative to 2000</i>			8%	22%	48%
<b>Per Capita Gross Emissions</b>	<b>20.5</b>	<b>22.4</b>	<b>22.1</b>	<b>22.7</b>	<b>23.4</b>

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

## Historical Emissions

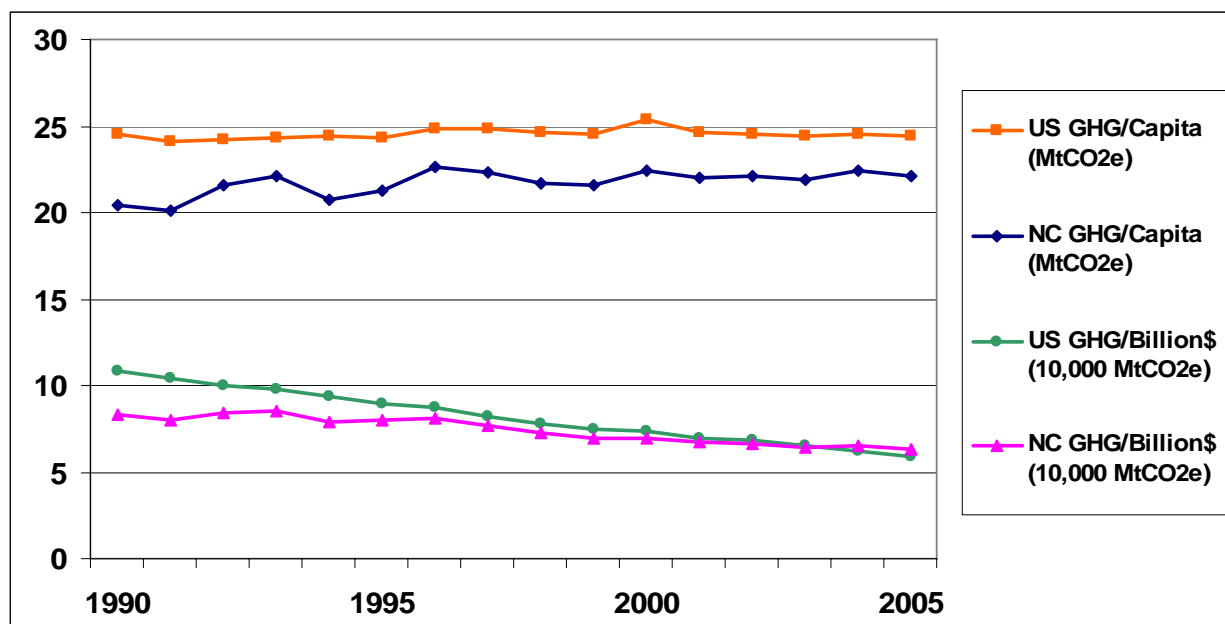
### Overview

In 2000, on a gross emissions consumption basis (i.e., excluding carbon sinks), North Carolina accounted for approximately 180 million metric tons (MMt) of carbon dioxide equivalent (CO<sub>2</sub>e) emissions, an amount equal to 2.5% of total United States (U.S.) gross GHG emissions. On a net

emissions basis (i.e., including carbon sinks), North Carolina accounted for approximately 156 MMtCO<sub>2</sub>e of emissions in 2000, an amount equal to 2.4% of total U.S. net GHG emissions.<sup>4</sup> North Carolina's GHG emissions are rising more quickly than those of the nation as a whole. From 1990 to 2000, North Carolina's gross and net GHG emissions were up 33% while national gross emissions rose by 16% during this period.<sup>5</sup>

On a per capita basis, North Carolinians emitted about 22 metric tons (Mt) of gross CO<sub>2</sub>e in 2000, less than the national average of about 25 MtCO<sub>2</sub>e. Figure 2-1 illustrates the state's emissions per capita and per unit of economic output. It also shows that, like the nation as a whole, per capita emissions have remained fairly flat, while economic growth exceeded emissions growth throughout the 1990–2002 period. From 1990 to 2000, emissions per unit of gross product dropped by 32% nationally and by 17% in North Carolina.<sup>6</sup>

**Figure 2-1. North Carolina and U.S. GHG emissions, per capita and per unit gross product**



The principal sources of North Carolina's GHG emissions are electricity use (including electricity imports in 2000) and transportation, accounting for 42% and 29% of North Carolina's gross GHG emissions, respectively, as shown in Figure 2-2.<sup>7</sup> The remaining use of fossil fuels—

<sup>4</sup> National emissions from *Inventory of US Greenhouse Gas Emissions and Sinks: 1990–2005*, April 2007, US EPA #430-R-07-002, available at: <http://www.epa.gov/climatechange/emissions/usinventoryreport.html>

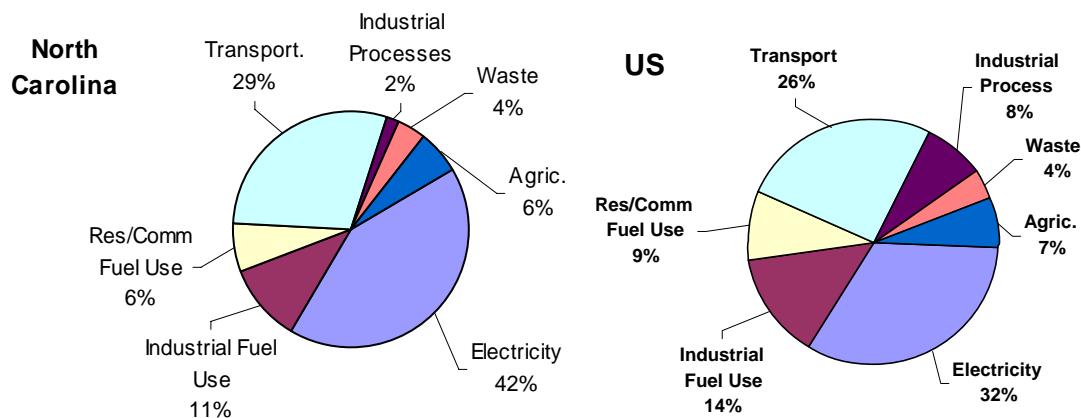
<sup>5</sup> During the 1990s, population grew by 21% in North Carolina compared with 13% nationally. Furthermore, North Carolina's economy grew faster on a per capita basis (up 60% vs. 52% nationally).

<sup>6</sup> Based on gross domestic product by state (millions of current dollars), available from the U.S. Bureau of Economic Analysis, <http://www.bea.gov/regional/gsp/>

<sup>7</sup> Gross emissions estimates include only those sources with positive emissions. Carbon sequestration in soils and vegetation is included in net emissions estimates.

natural gas, oil products, and coal—in the residential, commercial, and industrial (RCI) sectors constitute another 17% of state emissions.

**Figure 2-2. Gross GHG emissions by sector, 2000, North Carolina and U.S.**



Notes: Res/Comm = residential and commercial fuel use sectors; Transport. = transportation sector; Agric. = agricultural sector; Electricity = electricity generation sector emissions on a consumption basis.

Emissions for the residential, commercial, and industrial fuel use sectors are associated with the direct use of fuels (natural gas, petroleum, coal, and wood) to provide space heating, water heating, process heating, cooking, and other energy end-uses. The commercial sector accounts for emissions associated with the direct use of fuels by, for example, hospitals, schools, government buildings (local, county, and state), and other commercial establishments. The transportation sector accounts for emissions associated with fuel consumption by all on-road and non-highway vehicles. Non-highway vehicles include jet aircraft, gasoline-fueled piston aircraft, agricultural and construction equipment, railway locomotives, boats, and ships.

Agricultural activities such as manure management, fertilizer use, and livestock (enteric fermentation) result in CH<sub>4</sub> and N<sub>2</sub>O emissions that account for another 6% of state GHG emissions. Industrial process emissions comprised about 2% of state GHG emissions in 2000, and these emissions are rising rapidly due to the increasing use of HFCs and PFCs as substitutes for ozone-depleting chlorofluorocarbons.<sup>8</sup> Other industrial processes emissions result from aluminum manufacturing; PFC use in semiconductor manufacture; CO<sub>2</sub> released during soda ash, limestone, and dolomite use; and SF<sub>6</sub> released from transformers used in electricity transmission and distribution systems. Landfills and wastewater management facilities produce CH<sub>4</sub> and N<sub>2</sub>O emissions accounting for the remaining 4% of the state's gross GHG emissions in 2000.

### **A Closer Look at the Two Major Sources: Electricity and Transportation**

As shown in Figure 2-2, electricity use in 2000 accounted for 42% of North Carolina's gross GHG emissions (about 75 MMtCO<sub>2e</sub>), which is higher than the national share of emissions from electricity production (32%). On a per capita basis, North Carolina's GHG emissions from electricity consumption are higher than the national average (in 2000, 9.4 MMtCO<sub>2e</sub> per capita vs. 8.1 MMtCO<sub>2e</sub> per capita nationally). The average North Carolinian used more electricity than the average U.S. resident (15,000 kilowatt-hours [kWh] per person per year compared with 12,000 kWh nationally in 2000). During the 1990s, electricity demand grew at a rate of 2.9% per

<sup>8</sup> Chlorofluorocarbons (CFCs) are also potent GHGs; however, they are not included in GHG estimates because of concerns related to implementation of the Montreal Protocol. See Appendix I in the *Inventory and Projections* report for North Carolina.

year, while electricity emissions grew 3.4% annually, reflecting an increase in emissions per kWh.

As noted above, these electricity emissions estimates reflect the *GHG emissions associated with the electricity sources used to meet North Carolina demands*, corresponding to a consumption-based approach to emissions accounting. For many years, North Carolina power plants have tended to produce less electricity than is consumed in the state; in the year 2000, for example, North Carolina imported 8% of the electricity consumed in the state. As a result, in 2000, emissions associated with electricity consumption (75 MMtCO<sub>2e</sub>) were higher than those associated with electricity production (70 MMtCO<sub>2e</sub>).<sup>9</sup>

While we estimate the emissions from both electricity production and consumption, unless otherwise indicated, tables, figures, and totals in this report reflect electricity consumption emissions. The consumption-based approach can better reflect the emissions (and emissions reductions) associated with activities occurring in the state, particularly with respect to electricity use (and efficiency improvements) and is particularly useful for decision making. Under this approach, emissions associated with electricity exported to other States would need to be covered in those States' accounts in order to avoid double counting or exclusions.

Like electricity emissions, GHG emissions from transportation fuel use have risen steadily from 1990 to 2005 at an average rate of 2.7% annually. Gasoline-powered vehicles accounted for about 72% of transportation GHG emissions in 2000. Diesel vehicles accounted for another 21% in 2000, air travel for roughly 6%, and the remainder of transportation emissions came from natural gas and liquefied petroleum gas (LPG) vehicles. As a result of North Carolina's rapid expansion and an increase in miles traveled during the 1990s, gasoline use has grown at a rate of 2.5% annually. Meanwhile, diesel use has risen 4.8% annually, suggesting an even more rapid growth in freight movement within the State.

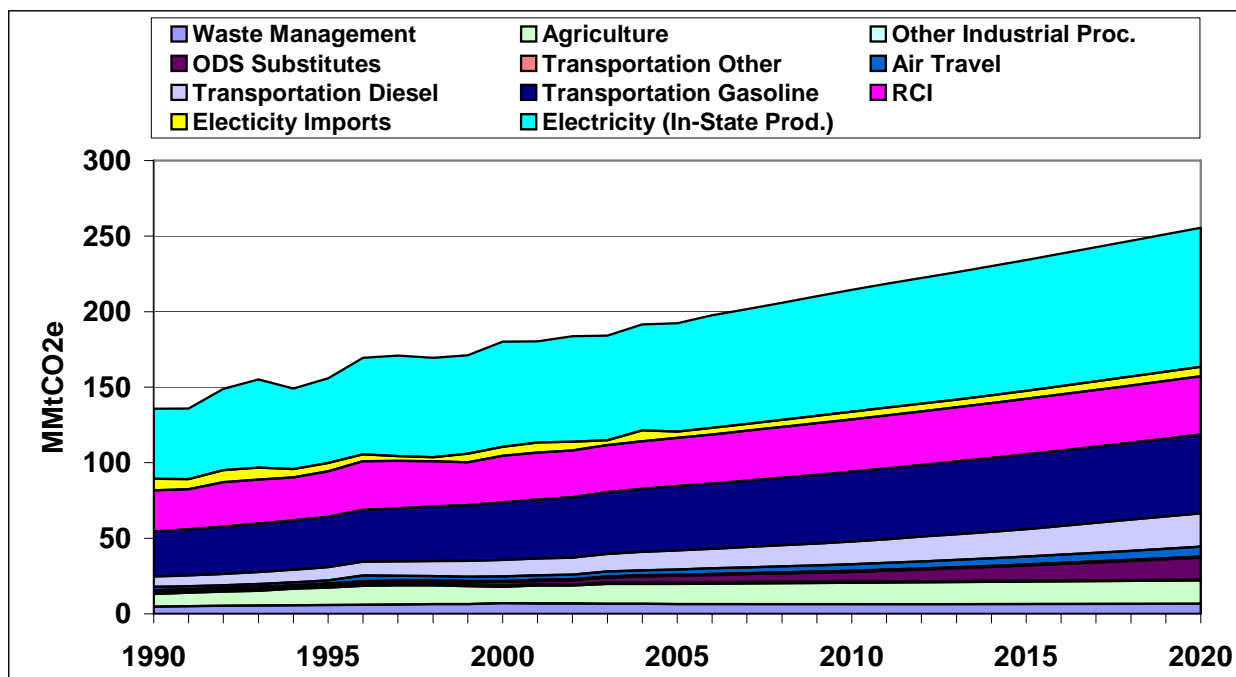
## Reference Case Projections

Relying on North Carolina agency projections of electricity and fuel use and other assumptions noted in the *Inventory and Projections* report, a simple reference case projection of GHG emissions through 2020 was developed. As illustrated in Figure 2-3 and shown numerically in Table 2-1, under the reference case projections, North Carolina's gross GHG emissions continue to grow steeply, climbing to 256 MMtCO<sub>2e</sub> by 2020, 88% above 1990 levels. Electricity is projected to be the largest contributor to future emission growth by far, followed by HFCs and PFCs used in place of ozone-depleting substances (ODS), as shown in Figure 2-4. Other major sources of emissions growth include transport (diesel), gasoline, and fuel use in buildings and industry (RCI). For the electricity supply sector, the increase in emissions after 2010 appears largely as the result of emissions associated with natural gas used to generate electricity by facilities in-state and emissions associated with electricity imported into North Carolina to meet North Carolina's demand for electricity (see Figure 2-5). After 2010, the use of coal and oil to generate electricity in-state is projected to remain at 2010 levels.

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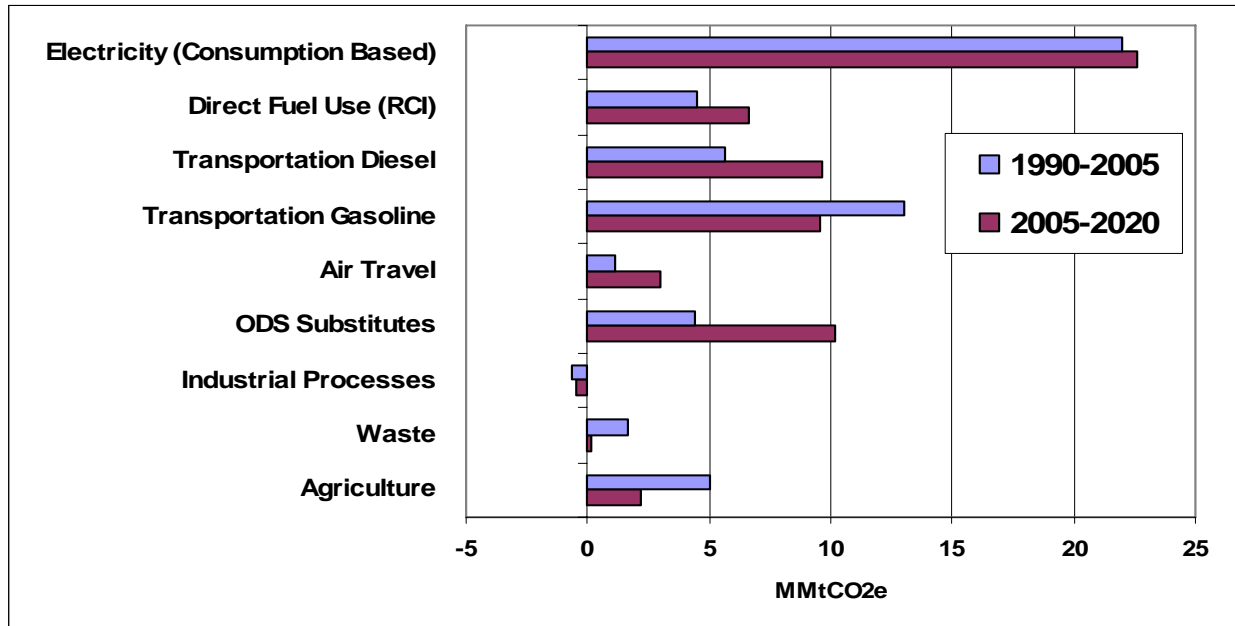
<sup>9</sup> Estimating the emissions associated with electricity use requires an understanding of the electricity sources (both in-state and out-of-state) used by utilities to meet consumer demand. The current estimate reflects some very simple assumptions described in Appendix A of *Inventory and Projections*.

**Figure 2-3. North Carolina gross GHG emissions by sector, 1990–2020: historical and projected (consumption-based approach) business as usual/base case**

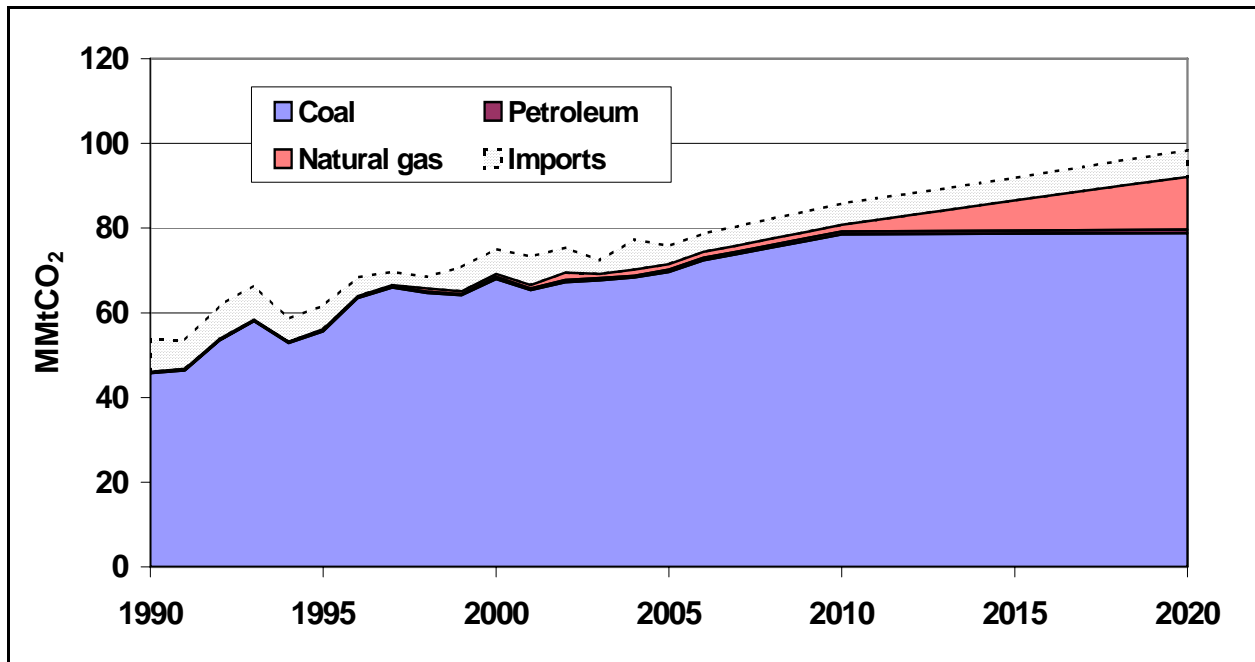


Overall, the average annual projected rate of emissions growth in North Carolina is 1.8% per year from the year 2000 to 2020. The increase in emissions after 2010 appears largely as the result of four factors: (1) electricity consumption (including imports) growth at a rate faster than population growth, (2) increasing use of vehicles with vehicle miles traveled (VMT) growing faster than population, (3) freight traffic growing faster than population, and (4) increasing use of HFCs and PFCs as substitutes for ODSs in refrigeration, air conditioning, and other applications. Other sources that are projected to grow faster than population are residential natural gas use, industrial fuel use, gasoline, air travel, and agriculture. Figure 2-6 illustrates how growth in net GHG emissions compares with growth in population and gross state product (GSP) for North Carolina.

**Figure 2-4. Sector contributions to emissions growth in North Carolina, 1990–2020: reference case projections**

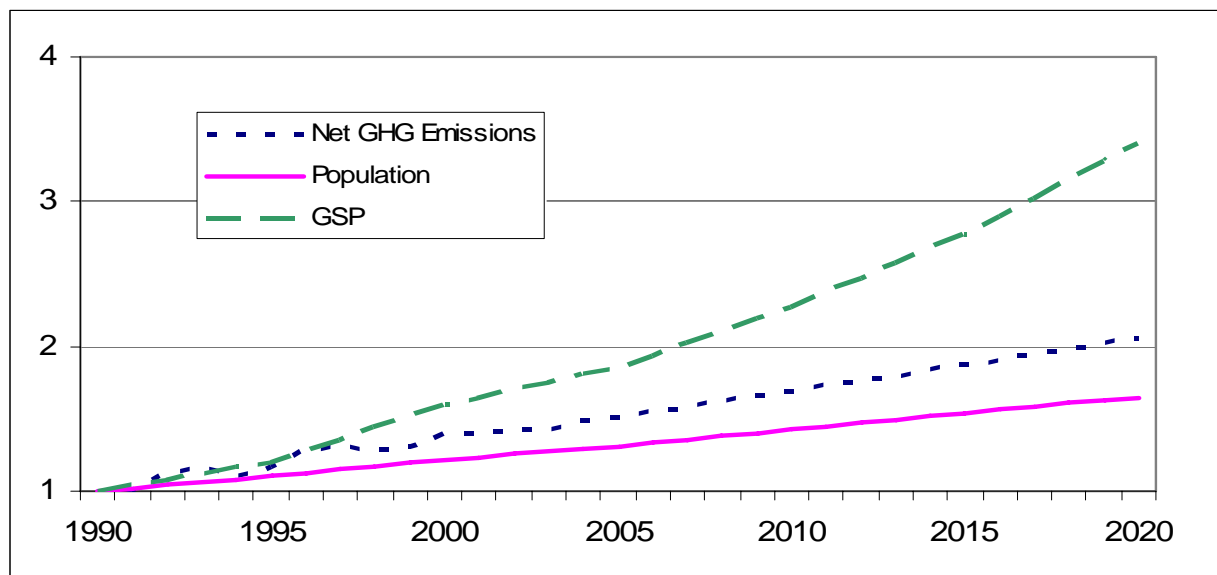


**Figure 2-5. Emissions from electricity consumption in North Carolina, by fuel source**



Note: Emissions associated with electricity generated from biomass are not shown in this graph because of scale effects. Emissions associated with biomass combustion are estimated to be about 0.03 MMtCO<sub>2</sub>e from 2003 through 2020.

**Figure 2-6. North Carolina historical and projected net GHG emissions, gross state product, and population (indexed to 1990 value, measured in MMtCO<sub>2</sub>e)**



## CAPAG Revisions

As a result of the CAPAG's and TWGs' review of the draft inventory and reference case projections, the CAPAG approved the following revisions:

**Energy Supply for 2003 Through 2020:** The Energy Supply TWG reviewed the inventory and forecast for the electricity supply sector and identified areas for improving the forecast for North Carolina. The CAPAG approved the revisions recommended by the TWG. The revisions improved the forecast of emissions for 2003 through 2020 associated with both in-state production and electricity imports. The revisions were to the fuel mix assumptions as well as to assumptions on transmission and distribution losses.

**Industrial Fuel Use for 1990 Through 2020:** When the first draft of the inventory and reference case projections was prepared, the EPA's tool for preparing emissions for 1990 through 2002 included independent power producers connected to the power grid. Emissions associated independent power producers were thus included in the industrial subsector for RCI. This category was also included in the energy supply sector in the first draft, following the Energy Information Administration (EIA) convention for defining sectors. In order to avoid potential double counting, the inventory and reference case projections were revised such that emissions associated with independent power producers were reported only with the energy supply sector, not with the industrial subsector for RCI. The U.S. Environmental Protection Agency (EPA) subsequently revised their tool for the RCI sectors to remove independent power producers.

Table 2-2 shows the change in emissions representing the difference between the revised emissions minus the draft emissions. Overall, the revisions approved by the CAPAG lowered 1990 emissions by 2.9 MMtCO<sub>2</sub>e, 2005 and 2010 emissions by 3.9 MMtCO<sub>2</sub>e, and 2020 emissions by 11.4 MMtCO<sub>2</sub>e.

**Table 2-2. Revisions to inventory and reference case projections (MMtCO<sub>2</sub>e)**

<b>Sector</b>	<b>1990</b>	<b>2000</b>	<b>2005</b>	<b>2010</b>	<b>2020</b>
Electricity Supply—In-State Production	0.0	0.0	-0.2	0.6	-5.3
Electricity Supply—Imports	0.0	0.0	0.3	0.3	-0.1
Industrial Fuel Use	-2.9	-3.4	-4.0	-4.8	-5.9
Total Change from Draft Inventory and Reference Case Projections	-2.9	-3.4	-3.9	-3.9	-11.4

**Industrial Processes Non-Fuel Use:** The CAPAG and RCI TWG added text to the discussion for this category in the final inventory and reference case projections report noting that, following international and national protocols, the GHG emissions associated with the use of ODSs are excluded from GHG inventories.

### **Key Uncertainties**

Some data gaps exist in this inventory, including 1990–1999 activity data for natural gas distribution and transmission. Key tasks, among others, include developing a better understanding of the electricity generation sources currently used to meet North Carolina loads (in collaboration with state utilities) and reviewing and revising key drivers, such as the electricity and transportation fuel use growth rates that will be major determinants of North Carolina’s future GHG emissions. Table 2-3 shows the key historical and projected growth rates affecting the North Carolina GHG emissions.

Perhaps the variables with the most important implications for GHG emissions are the type, size, and number of power plants built in North Carolina between now and 2020. There are also significant impacts associated with projecting electricity consumption in the state, as well as in the estimation of consumption-based electricity emissions (i.e., which electricity sources serve North Carolina loads). If a consumption-based emissions approach is adopted by the state, further analysis should be directed toward resources that utilities use to meet North Carolina loads and methods that can be reliably used to track them.

Emissions of aerosols, particularly black carbon from fossil fuel combustion, could have significant impacts in terms of radiative forcing (i.e., climate impacts). Methodologies for conversion of black carbon mass estimates and projections to global warming potential involve significant uncertainty at present, but CCS has developed and used a recommended approach for estimating black carbon emissions based on methods used in other States. At this time, no estimates have been developed for North Carolina. By including black carbon emission estimates in the inventory, additional opportunities for reducing climate impacts are realized.

**Table 2-3. Key annual growth rates for North Carolina, historical and projected**

	<b>1990–2000</b>	<b>2000–2020</b>	<b>Sources/Uses</b>
Population	2.0%	1.5%	North Carolina Office of State Budget and Management
Gross state product	4.8%	3.9%	<i>North Carolina Energy Outlook 2003</i> (not used for projections)
Employment	2.6%	1.3%	<i>North Carolina Energy Outlook 2003</i>
Electricity sales	2.9%	1.5%	U.S. Department of Energy (US DOE) Energy Information Administration (EIA) State Energy Data (SED) for historic, Annual Report of the North Carolina Utilities Commission for projections
Vehicle miles traveled	n/a	2.4%	Federal Highway's Highway Performance Monitoring System (HPMS) and North Carolina DENR