CO_2 Emission Reduction Options For Coal-fired Electrical Utility Boilers and Other Stationary Sources

First Interim Report

September 1, 2003

North Carolina
Department of Environment and Natural Resources

Division of Air Quality
1641 Mail Service Center
Raleigh, North Carolina 27699-1641

The Requirement: Excerpted from the Clean Smokestacks Act

[**Title**: 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]

SECTION 13. The Division of Air Quality of the Department of Environment and Natural Resources shall study issues related to the development and implementation of standards and plans to implement programs to control emissions of carbon dioxide (CO_2) from coal-fired generating units and other stationary sources of air pollution. The Division shall evaluate available control technologies and shall estimate the benefits and costs of alternative strategies to reduce emissions of carbon dioxide (CO_2). The Division shall annually report its interim findings and recommendations to the Environmental Management Commission and the Environmental Review Commission beginning 1 September 2003. The Division shall report its final findings and recommendations to the Environmental Management Commission and the Environmental Review Commission no later than 1 September 2005. The costs of implementing any air quality standards and plans to reduce the emission of carbon dioxide (CO_2) from coal-fired generating units below the standards in effect on the date this act becomes effective, except to the extent that the emission of carbon dioxide (CO_2) is reduced as a result of the reductions in the emissions of oxides of nitrogen (NOx) and sulfur dioxide (SO_2) required to achieve the emissions limitations set out in G.S. 143-215.107D, as enacted by Section 1 of this act, shall not be recoverable pursuant to G.S. 62-133.6, as enacted by Section 9 of this act.

GENERAL ASSEMBLY OF NORTH CAROLINA - SESSION 2001 – (SENATE BILL 1078)
Ratified the 19th day of June 2002. (Ch. SL 2002-4 S.13)
Marc Basnight - President Pro Tempore of the Senate
James B. Black - Speaker of the House of Representatives
Michael F. Easley - Governor

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Send comments to the above address or email to
NCCSA_CO2@ncmail.net

Introduction from DENR Secretary William G. Ross

North Carolina Department of Environment and Natural Resources
Michael F. Easley, Governor William G. Ross, Jr., Secretary

September 1, 2003

TO: Environmental Review Commission
Environmental Management Commission

FROM: William G. Ross Jr.

SUBJECT: Mercury and CO_2 Reports Required by Clean Smokestacks Act

When the North Carolina General Assembly passed, and Governor Easley signed the Clean Smokestacks Act in June of 2002, our State took two crucial steps toward addressing several of the most pressing environmental and public health issues of our time. One step was highly visible, the other less so.

The visible step was to attack the problems of ozone, smog and pollution from fine particles by requiring North Carolina's fourteen coal-fired power plants to make deep cuts in sulfur dioxide and nitrogen oxides, and to do so quickly. The utility companies swung into action and are on schedule to achieve the required reductions.

The less visible, but nonetheless crucial, steps that North Carolina took under the leadership of the General Assembly and Governor Easley was to call for our state to address the issues related to the emissions of carbon dioxide from coal-fired power plants and other stationary sources also related to the emissions of mercury from power plants. Under the new law, our department, through our Division of Air Quality, will study and make findings and recommendations on both subjects in reports due in September 2003, 2004 and 2005. We are this week issuing the 2003 reports on CO_2 and mercury.

Why is it crucial that North Carolina address emissions of CO_2 and mercury? In my view it is crucial that we focus on the biggest problems facing us, and mercury and carbon dioxide emissions seem clearly to be among our biggest problems. With mercury, there is a growing concern about its impacts on public health. With carbon dioxide, there is the concern that we are changing the climate in a manner and pace that are unprecedented.

In his 2002 book, The Earth Remains Forever, Professor Rob Jackson of Duke University frames the question this way:

"Based on current scientific evidence, I believe that by the end of the twenty-first century:

I. There will be at least nine billion people on earth.

II. Annual global energy use will be at least fifty percent higher per capita than at the end of the twentieth century, and total energy consumption will triple.

III. Atmospheric carbon dioxide concentrations will be more than five hundred parts per million, double the pre-industrial levels and higher than at any time in the past forty million years. In consequence, the average temperature of the earth will be at least 5° F warmer.

IV. Thousands, perhaps millions, of species will be extinct.

V. The demographic and economic momentum behind these changes is immense." (p 129)

"Most of all, I want to know that we did our best, that we tried everything we could to preserve the quality of life for people today and tomorrow and saved as much room as possible for the rest of life on earth. Who doesn't want this? The moral, the practical, the ultimate question is what we do about it, what we will give up today so that we and our descendants and the rest of life on earth may have their tomorrow." (p.132)

Thanks to the leadership of the General Assembly and Governor Easley, our state is a national leader in reducing emissions of SO_2 and NOx from coal-fired power plants. To answer Professor Jackson's question, we are doing our best as a state on these two issues.

What will we do about mercury and carbon dioxide? Thanks again to our legislators and the Governor, we also have a chance to answer Professor Jackson's question, this time for mercury and carbon dioxide in a similar, positive way.

We appreciate your attention to these two reports. We look forward to your comments and questions about them.

Thank you.

Preface

This 2003 report has been produced by a working group within the North Carolina Division of Air Quality (DAQ). Stakeholders from both Duke Energy and Progress Energy, environmental interests (e.g. Environmental Defense Fund, Sierra Club etc.) and other organizations (e.g. NC Utilities Commission, State Energy Office, Global Warming Initiatives, Advanced Energy, Inc., etc.), through an open call, were invited to provide their insights, comments and input. The Division appreciates the efforts of all the stakeholders and other individuals who committed their time and effort to the development of this preliminary report. This open process will continue in the development of subsequent and final reports on this topic.

Many portions of this document were taken directly from other government (non-copyrighted) documents in the interest of time and completeness. Some of these sections may have only minor wording changes from the original documents. Quotations are not strictly used to identify these parts, but a strong effort was made to reference these documents and acknowledge them. The purpose has not been to claim credit for original work of others, but to provide as much detail and accuracy as possible within a limited time.

The objective of the 2003 report is to provide a general background ("state of knowledge") and to define the scope of efforts needed to address and respond to the legislative requirements. This 2003 report is a first step and will be followed with reports in 2004 and 2005 that build on the background contained in this report, on the increasing state of knowledge, on developments in the federal sector and on any courses of action that may follow. The 2003 report is the first step in a three-step process to study issues and make findings and recommendations related to the development and implementation of standards and plans to implement programs to reduce emissions of carbon dioxide from coal-fired power plants and other stationary sources of air pollution.

The 2004 report is due to the Environmental Management Commission and the Environmental Review Commission (of the Legislature) in September 2004. We expect to base that report on input from a proposed workshop (with presentations by DAQ, stakeholders and other state and outside experts) hosted by DAQ, in the spring of 2004, with supplemental information and summaries provided by DAQ staff. A third and final report, the 2005 report, will then be prepared by September 2005 and include findings and recommendations that build upon the 2003 and 2004 reports.

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Acronyms Used in This Report

AEFL - Amine-Enhanced Flue Lean Gas Reburn
CAA – Clean Air Act – Primary federal statute governing clean air requirements
CAPA – Clean Air Planning Act – Carper Bill
CCAR – California Climate Action Registry
CEM – Continuous Emission Measurement
CO_2 – Carbon Dioxide – the major global warming gas
CPA – Clean Power Act p Jeffords-Waxman Bill
CSA – NC Clean Smokestacks Act (Also see CSI, below)
CSI – Clear Skies Initiative – Proposal for revised CAA legislation by the Bush Administration (also recently referred to as Clean Skies Act, though not yet an actual Act)
DAQ – NC Division of Air Quality
DENR – NC Department of Environment and Natural Resources
DOA – Department of Agriculture (US and NC)
DOE – The US Department of Energy
EPA – US Environmental Protection Agency
GHG – Global Warming Gas(s)
GWP – Global Warming Potential
HFC's - Hydroflurocarbons
HVAC – High Volume Air Conditioning
IPCC - Intergovernmental Panel on Climate Change, international authority on climate change
LNB – Low NOx Burner
NAAQS – National Ambient Air Quality Standards
NAS - National Academy of Science
NC – North Carolina
NCSU – North Carolina State University
NESCAUM - Northeast States for Coordinated Air Use Management
NHCPS – New Hampshire Clean Power Strategy
NOx – Oxides of Nitrogen, including NO_2, the primary nitrogen species from combustion
OFA – Overfire Air
PFC's - Perfluorocarbons
ROFA – Rotating Opposed-Fired Air
ROTAMIX – Injection of Ammonia to further reduce NOx (Used in combination with ROFA)
RPS – Renewable Portfolio Standard
SCR – Selective Catalytic Reduction
SCRUB – Wet scrubber for SOx
SEO – State Energy Office of NC
SNCR – Selective Non-Catalytic Reduction
SOx – Oxides of Sulfur, including SO_2, the primary combustion product of sulfur
SUV – Sport Utility Vehicle
TFS2000 – Combination Low-NOx Burner/Overfire Air
UNFCCC - United Nations Framework Convention on Climate Change
WIR - Underfire Air

Super Summary

The NC DENR Division of Air Quality (DAQ) is required to provide three reports to the Environmental Management Commission and the Environmental Review Commission, by September 1, 2003, 2004 and 2005, addressing issues related to the development and implementation of standards and plans to control CO_2 emissions from coal fired utility boilers and other stationary sources of air pollution. This is the first of those three reports.

- The Executive Summary of this report provides a list of the major points determined to date:
  - Global warming/climate change is a real concern. (See background in Appendix)
    - Continually increasing man-made greenhouse gas emissions are an important causal factor in this phenomenon.
    - These conclusions are supported by a broad, but not unanimous, scientific consensus.
    - It is prudent that steps be taken to mitigate these changes.
    - The NC Legislature has recognized the seriousness of the problem and initiated these efforts to help determine ways to mitigate the problem.
    - Other sources of CO_2 and other global warming gases will need to be addressed in the overall solution.
  - CO_2 emissions occur when any carbon-based fuel is burned.
    - Coal fired power plants account for a major portion of the CO_2 emissions in the state.
    - Mobile sources, residential, industrial and commercial buildings and related facilities, agricultural burning and forest fires are also important direct CO_2 sources.
    - Buildings and facilities are also major consumers of electricity and, thus are indirect sources of CO_2.
  - Conventional "end of stack" emission controls applicable to reduction of CO_2 are not currently available, but research continues.
  - Reduction in energy consumption is a prime means for reduction in CO_2 emissions from coal fired power plants and other fossil fuel burners; whether by conservation, efficiency technologies or other means.
  - It is important that any solutions offered for use in NC be such that they can be integrated and synchronized with national/federal (and even international) efforts, particularly as they may apply to companies and other entities that have locations in multiple areas.
  - A number of other states are undertaking CO_2 reduction efforts. These efforts take a variety of forms and are described in Chapter 3.

- Further studies by the DAQ, stakeholders, universities and other interested parties over the next two years should provide valuable insights and recommendations into what is feasible, cost-effective and appropriate for North Carolina utilities and other stationary sources, relative to the best means to control and mitigate CO_2 emissions.

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Chapter 1 Executive Summary

Summary of Statute

Chapter 2 The North Carolina (NC) Clean Smokestacks Act (CSA)[1] requires the NC Division of Air Quality (DAQ) of the Department of Environment and Natural Resources (DENR), to study issues related to the development and implementation of standards to control emissions of carbon dioxide (CO_2) from coal-fired generating units and other stationary sources of air pollution. (See the inside front cover for the actual language for the applicable section of the Act.) The NC DAQ is required to evaluate available control technologies and estimate the benefits and costs of alternative strategies to reduce emissions of carbon dioxide (CO_2). The findings of these studies and related recommendations are to be included in three reports to the Environmental Management Commission (EMC) and the Environmental Review Commission (ERC), annually, starting September 1, 2003 and continuing through September 1, 2005.

Emissions of global warming gases (GWG), especially CO_2, have been increasing proportional to man's population and sophistication. Many of these changes have happened almost without notice, just as the frog in the pot of water is not aware of the changes that take place gradually as it is heated to boiling. Though there are ways that CO_2 may be removed from the air ("sinks"), the emission side of the equation has been gaining rapidly in the last several decades, as is reflected in measurements in the ambient air. Forensic air quality scientists, who look at temperature measurements, concentrations in glacial air bubbles, and other means, tell us that atmospheric concentrations have risen almost by a factor of two in just the last century or so.[2] There are many off-setting causes of changes in CO_2 and the average global atmospheric temperature of the Earth, but many of the world's most recognized and respected scientists have declared that global warming/climate change is a real and growing problem that must be addressed soon. Otherwise, we will be like the frog and eventually face a less than desirable result. The challenge is difficult. However, the NC General Assembly has given us the charge to try to find ways to reverse this trend. At the end of the three years, the DAQ hopes to be able to make solid recommendations to assist in achieving this end.

Scope & Objectives of This and Future Reports

This report is intended to provide the background and 'state of the science' information on CO_2 emissions. The purpose is not to establish new scientific findings, but instead to identify and summarize work already accomplished by others and apply it to North Carolina. We hope to present objective analyses and conclusions to help the EMC, the ERC, the General Assembly and our state sort through the facts and issues in order to arrive at reasonable and prudent actions and recommendations for action. The intent is that these recommendations and actions precipitate actions that will conserve and protect our natural resources and maintain a high quality environment for the health and well-being of all North Carolinians.

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[1] SECTION 13, Clean Smokestacks Act; General Assembly of North Carolina - Session 2001 – (SENATE BILL 1078), Ratified the 19th day of June, 2002.

[2] Rob Jackson, The Earth Remains Forever, University of Texas Press, 2002.

The phenomenon of global warming (**"Climate change")** has been widely accepted by the scientific community worldwide. However, technical issues related to the severity of the impacts associated with global warming or climate change can generate extended discussion. The topic of this report is not one to study in isolation. Climate change in North Carolina is not affected by science and conditions that pertain just to this state or just within the state's boundaries. Actions in other states and regions, and on the national and international level, will be required for changes made in North Carolina to realize their full potential to protect the health of our citizens and our environment. However, studies and NC's experiences with other air pollutants have shown that cleaning up at home first provides the most benefits to a state and can lead the way to action on a much broader scale. Eileen Claussen of the Pew Center on Global Climate Change recently summarized the issues current status of climate change understanding and emphasized that the debate has shifted from "whether to do something" to "what to do and when to do it."[1] A background discussion summarizing more of the scientific background and consensus is contained in the Appendix to this report.

Federal Actions and Requirements

There are currently no federal standards for the control of carbon dioxide emissions or for the broader group of Greenhouse Gases (GHG). However, much effort has been expended on this topic within the national and international arenas in the past 25-30 years. During these times various reduction strategies have been developed and promoted, registries have been implemented, and research continues, but no significant and specific federal mandates currently exist to control them in the United States. Efforts to formalize and finalize subscription to international treaties related to international registries and to tracking and reducing GHG have not been (and may not be) completed by the US. However, significant research continues and efforts to refine existing federal registries to allow for reductions in GHG by cap and trade programs appear to be gaining momentum. Significant announcements of efforts to expand the program and provide more uniform and universally interchangeable quantification and certification of such emissions are expected from the US Department of Energy (DOE) soon.

The Kyoto protocol is frequently mentioned in regard to climate change and to track and mitigate emissions. The US has participated in several world conferences dealing with global climate change.[2] In Kyoto, Japan, in 1997, most industrial countries of the world tentatively agreed to undertake efforts to lower their GHG productions to, or below, 1990 levels. Negotiators for the US tentatively proposed to reduce emissions by 7% below 1990 emissions level, and to achieve this target between 2008 and 2012. However, the treaty has not been ratified by the United States. The Bush Administration made significant changes in the U.S. position. These changes would delay or preclude the treaty from being ratified by the U.S. at all.

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[1] Eileen Claussen, "Climate Change: Then and Now," A speech to the Environmental Council of the States (given in Salt Lake City); Pew Center on Global Climate Change, Washington, D.C., August 2003

[2] North Carolina's $ensible Greenhouse Gas Reduction $trategies Executive Summary, Appalachian State University, Department of Geography and Planning, Boone, NC, January 2000.

Additionally, in late July 2003, the Administration released a new plan. This plan focuses on additional research in several areas. However, some critics view it as a delay tactic.[1] Thus, the current position does not provide for U.S. support of the Kyoto accord. More on this topic is discussed later in this report.

Provisions of the Clear Skies Initiative (**CSI** - proposed by President George W. Bush - now also known as Clean Skies Act) and several bills that have been introduced into the U.S. Congress contain proposals for mitigation of CO_2. These are also referred to as the "multi-pollutant" bills or other variations of this term. The four pollutants involved are NOx, SOx, mercury and CO_2. Whether federal legislation will be enacted, and if so, whether it will address CO_2 and other GHG is unknown at this time.

Efforts by Other States

Several states have developed their own legislation and regulations, in spite of potential incongruence with proposed efforts at the federal level. Some observers have described the current level of state activity as "striking,"[2] in contrast to the lack of decisive federal actions. The cited Pew Center report discusses nine states with state-level initiatives, including NC. The NC reference is specifically for methane considerations from animal waste operations being researched at NCSU under the Smithfield Agreement. Efforts in these and other states (21 states are discussed individually later in this report) have covered a wide range, but typically, include development of registries, implementation of programs with specific targets, and promotion of the steps necessary for reduction of CO_2 and other GHG.

States often appear to be motivated not only by a sense of urgency to do something about the climate change, but also by the economic, social and environmental benefits that accompany reductions in GHG. These include cleaner air, cost savings from energy efficiency, marketing opportunities for renewable energy and other reasons that may sometimes seem unrelated to climate change. Many of the state programs to address climate change that exist today are part of an economic development strategy designed for the longer term. Renewed efforts toward a unified national and internationally acceptable registry with defensible reduction and tracking programs for these gases could result in less confusion and increased efforts to revamp existing programs. Resulting estimates could then be more universally compatible and be able to be banked and traded in a formal and certified manner. This topic is also discussed later in this report with state-by-state notes summarizing the major activities underway.

In an interesting, and possibly important recent development, attorneys general from the states of Connecticut, Maine and Massachusetts filed suit in federal district court in Connecticut (June 4, 2003) against EPA for its "failure to regulate carbon dioxide (CO_2) under the Clean Air Act." According to the lawsuit[3], EPA has acknowledged both that CO_2 emissions pose a serious

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[1] John Heilprin , "White House Wants More Research on Nature's Role in Global Warming"; Associated Press, Raleigh News and Observer; Raleigh, NC, July 25, 2003.

[2] Barry G. Rabe, Greenhouse & Statehouse: The Evolving State Government Role in Climate Change, University of Michigan and the Pew Center Global on Climate Change, November 2002

[3] Commonwealth of Massachusetts, State of Connecticut and State of Maine, Civil Action v. Christine Todd Whitman, in her capacity as Administrator of the United States Environmental Protection Agency, Defendant, United States District Court, District of Columbia, June 4, 2003.

risk to human health and that it has authority to regulate CO_2 emissions under the Clean Air Act (CAA). Accordingly, the suit claims that EPA has a mandatory duty to regulate CO_2 emissions under the CAA. If the lawsuit succeeded, EPA would have to list CO_2 as a criteria pollutant and develop a national ambient air quality standard for it. Since all health related impacts of the GHG appear to be "indirect," an entire new process would need to be developed to set such standards. Historically, this process has taken 10-15, or more, years to reach implementation.

Since the suit mentioned above and in a separate action, EPA has issued a ruling that CO2 is not an air pollutant subject to listing and regulation as a criteria pollutant under the Clean Air Act. Though the intent or effect may tend to be preemptive, this ruling was not as a result of the separate action still being (to be) considered in the court.

North Carolina Actions to Date

Little has been done from a programmatic or regulatory standpoint to mandate reduction of CO_2 emissions from coal-fired power plants or other sources. An effort by North Carolina to pursue participation in a climate change registry was initiated in 1994-1995 with a program called ***Climate-Wise***, a means to enter emissions into the US DOE registry and bring mitigation options to the attention of the participants, but this program has not included utility units. A number (39) of companies agreed to (and continue to) participate in this effort. However, the formal (financial) state support of this program has been cut. A private non-profit corporation was recently formed to continue the participation of these companies in this effort, on a voluntary basis. Since many of the results of this type of program tend to pay for themselves in cost savings, the state may need to look for ways to resume funding of this program. Other related energy (CO_2 generation) use reduction programs in place in the state are described in more detail later in this report.

In the 2003 North Carolina General Assembly, legislation was introduced, but never acted upon, to rekindle a "voluntary" state registry program for GHG. The bill recognized the possibility that GHG registration might become mandatory later. Coal fired utility boilers are a large contributor to this emission pool. However, these plants are already required to report their CO_2 emissions annually (the only GHG reported) to the EPA Acid Rain Program (Title IV of the Clean Air Act), which then reports these emissions. Other related efforts are underway and proposed regarding energy conservation and a state energy policy/plan. Such efforts are closely correlated to potential reductions of CO_2 in the state. More details are provided in later chapters.

Summary of Preliminary Findings and Plans

In this first report, no new and original scientific or technical findings are presented. (A background summary of what we perceive to be the underlying scientific consensus concerning climate change is included as an Appendix.) Judgments in this report are made using existing information and are based primarily on the work of others. Such judgments and findings will be refined and applied to North Carolina during the preparation of the 2004 and 2005 reports. This document has undergone a brief stakeholder participation process, but it was not subject to public hearings or other such reviews and participation. Future reports will be prepared with participation and input from stakeholders, members of the public, universities and other interested parties.

To date, we have concluded that the following are reliable statements on the issues:

- Leading national and international science authorities have concluded that man-made emissions contribute to climate change and that it is prudent to take steps to reduce those emissions. The accepted science and background information are discussed in more detail in the Appendix.
    - The Intergovernmental Panel on Climate Change's (IPCC) Working Group I has provided several conclusions related to the evidence of climate change phenomena and encourages mitigation actions. The panel concluded "An increasing body of observations gives a collective picture of a warming world and other (man-made) changes in the climate system." [1]
    - The Bush Administration commissioned and supports the conclusions of the National Academy of Science's (NAS) report entitled "Climate Change Science," which restated the IPCC conclusions and encourages reductions of GHG.
    - The Bush Administration's "US Climate Action Report 2002"[2] accepts and supports the conclusions of the above NAS report ("Greenhouse gases are accumulating in Earth's atmosphere as a result of human activities, causing global mean surface air temperature and subsurface ocean temperature to rise.")
    - CO_2 in the atmosphere (as well as other GHG) has continued to increase significantly over the last 100 years, especially in the latter half of the century (1950-2000). [3]
    - Despite the strong and growing scientific consensus, many still debate the severity of impacts from increased GHG, including CO_2[4], and what should be done in response to rising GHG levels.

- The NC General Assembly has directed DENR/DAQ to study issues related to the development and implementation of standards and plans to implement programs to control emissions of carbon dioxide from coal-fired generating units and other stationary sources. Here are some preliminary observations concerning the issue:
    - Climate change is a concern at all levels, from local to global, and must be addressed at local, state, national and international levels, with coordinated leadership contributing to efficient reductions.
    - Though a substantial effect from human activities is accepted, it is also necessary to recognize the Earth's underlying natural cycles of warming and cooling, but not to use this as an excuse for inaction.
    - The Kyoto Protocol has been signed by a majority of producers of GHG but not the United States.
    - Options for reducing GHG emissions include conservation, process changes, development and adoption of new technologies and other approaches at all levels of society.

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[1] Climate Change 2001: The Scientific Basis, Intergovernmental Panel on Climate Change (IPCC), 2001

[2] Climate Action Report, http://yosemite.epa.gov/oar/globalwarming.nsf/content/ResourceCenterPublicationsUSClimateActionReport.html, US Department of State, Washington, DC, May 2002.

[3] Climate Change: State of Knowledge; Office of Science and Technology Policy; Office of the President, Washington, D.C., October 1997.

[4] Status of the Kyoto Protocol; The United Nations Framework Convention on Climate Change, July 2003.

- CO_2 is only one of several (usually identified as 5 major[1]) greenhouse gases that affect the climate, but the CSA only addresses CO_2.
- The observed rise in CO_2 in the atmosphere is largely attributable to human activity, mainly the burning of fossil and other carbon fuels that release CO_2, though natural sources exist as well. Major anthropogenic sources include:
  - Fossil-fueled (and other carbon-based fuels) utility and other boilers,
  - Carbon-based-fueled internal combustion engines (automobiles, trucks, construction equipment, boats, lawnmowers, etc);
  - Incineration of refuse, prescribed burning, agricultural burning and other forms of combustion; and
  - Many industrial processes, especially those such as the petroleum refining and the petrochemical industry, where large quantities of carbon fuels are used.
- A distinction is normally made between fossil fuel combustion and "renewable" fuels, although combustion of one atom of carbon from any fuel (e.g. wood or alcohol) produces one molecule of carbon dioxide.

- Emission estimates are crucial for the analysis and management of CO_2.
  - CO_2 emissions are relatively easy to quantify (within a reasonable margin of error) by estimation and calculations;
    - However, few facilities are monitored by continuous emission measurement (CEM) instrumentation.
    - Protocols for estimation are not universally adopted which contributes to some imprecision, but the disagreements are generally minor.
  - Title IV of the Clean Air Act (1990 Amendments) requires coal-fired electric utilities to report CO_2 estimates to the US Environmental Protection Agency (EPA) annually;
    - A database of this information is publicly available from the EPA.
  - The emissions of CO_2 in North Carolina from known sources have been quantified by multiple studies.
    - These studies provide data that are acceptable for purposes of problem assessment,
    - However, for emission trading purposes, the protocols and documentation standards required may be inadequate.
  - EPA has compiled emission estimates of GHG for NC as part of a national effort.
    - EPA updates these estimates annually.
    - The initial effort used contract assistance from Appalachian State University.
      - That effort reflected review comments from the DAQ.
  - The US DOE and EPA promote, encourage and maintain registries of CO_2 and other emissions of GHG.
    - These registries are now separate and not identical in participation requirements and calculation standards or protocols.
    - They have a low probability to be merged into a combined national registry sometime in the future as would be desirable.

[1] Emissions of Greenhouse Gases in the United States 2001, DOE/EIA-0573, US DOE, Energy Information Administration, Washington, DC, December 2002.

- Several states have established their own registries (and mitigation activities) to address these gases, with 1990 (the baseline date in the Kyoto Protocol) being a common reference year.
- A program called "***Climate Wise***" was developed by NC's Energy Office to provide a climate change gases registry program in 1994,
  - It was later discontinued due to budget cuts.
  - A "re-born" program is continuing via the private sector with a non-profit organization (Global Warming Initiatives, Inc.).
- Other energy savings programs exist (and have been proposed) in NC that contribute, or have the potential to contribute, to the reduction of GHG emissions. For example, the proposed **NC Energy Plan** is closely aligned with these and based on similar principles. This report provides more detail in later discussions.

- Currently, reductions in emissions of CO2 are expected to most likely come from energy efficiency improvements and other measures to reduce fuel consumption.
  - When combustion occurs, carbon chemically bonds with oxygen to form CO_2 and releasing useful heat. CO_2 cannot be converted to a more desirable form (i.e. "unburned") without using up energy. Complete removal would require an equal or greater consumption of energy than was generated to burn it in the first place.
  - The recognized most effective way to "control" CO_2 is to refrain from or reduce burning of carbon-based fuels.
  - Many programs have successfully demonstrated the feasibility of increasing energy efficiency and reducing waste in order to burn less with the same product output.
  - Research studies of ways to collect and dispose of CO_2 in an acceptable manner are promising, but such processes would likely be very costly.
  - Scrubbers that control or reduce NOx or SO_2 emissions are not effective in significantly reducing CO_2.
    - Such scrubbers actually add a CO_2 penalty in that the increased power requirements for pumps, blowers, etc., affiliated with these controls reduce the net output of the facility by about 1%.
  - Several DOE (and other) research projects aim to
    - Increase efficiency of utility boilers and,
    - Control the gases by new and innovative methods (such as injection of the stack effluent into deep underground coal seams or brine pools).
    - However, these have not yet been proven successful or economically practical.
  - Policy changes that are under consideration for legislative actions nationally will likely have important impacts on NC efforts.

Therefore, DENR/DAQ expects to pursue the general course below following this initial report. This plan is a combination of several immediate actions and tracking of various efforts by others, in NC and elsewhere. We will build upon this report in the 2004 and 2005 reports. These actions include:

- To continue to recognize CO_2 as the most predominant climate change gas, especially for coal fired utility boilers addressed by the CSA,
- To acknowledge the importance of other climate change gases, such as methane.

- To continue to follow, evaluate and provide updated information regarding any breakthroughs in legislation or control technology research by federal and international organizations, especially those that might be promising for CO_2 reductions from NC sources.
- To continue to evaluate methods and programs (new and existing, such as ***Energy Star Partners***, ***Climate Challenge***, ***Green Power Program***, ***Climate Leaders***, and ***Climate-Wise, as related to the NC Energy Plan)*** - that can lead to reduction of CO_2 by energy efficiency increases, waste reductions, changes in processes (or product characteristics), etc. We expect that DAQ will be able to develop a basis to make other recommendations on ways to adopt and promote such methods and programs in NC, considering the environment and economy.
- To explore further concepts and actions to sequester carbon within the state, including but not limited to planting policies, species selection and other actions as have been initiated by NC State University (NCSU), the NC Department of Agriculture (DOA), DENR/Division of Forest Resources, etc., and make further recommendations as warranted.
- To continue to investigate alternative approaches and make recommendations for NC to take to establish/expand and otherwise participate in a registry of greenhouse gases.
- To explore the feasibility and effectiveness of statewide goals for reduction of GHG.
- To hold a broadly based (NC DAQ, stakeholders, other NC and outside experts) conference on CO_2 and Mercury in the spring of 2004 and use the results of this workshop in preparing the 2004 report.

Chapter 2 North Carolina Emission Sources and Characteristics

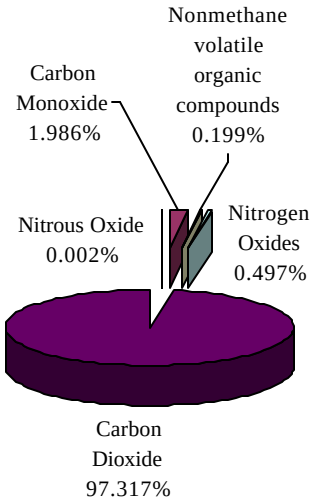
Databases Available and Used

Emissions of CO_2 are generally estimated, not measured. Consequently, there is always some level of uncertainty. However, because fuel use, and thus carbon, relate to operating costs, usage is generally tracked carefully, making estimation a relatively accurate way to determine CO_2 emissions. Several sources of information and data are available for coal fired utilities. The first is the Acid Rain data required by Title IV of the Clean Air Act.[1] These data are reported annually by each coal-fired power plant for each boiler. This information is available from EPA on the Internet. The second source is a series of reports annually published by EPA that use these data and other data to produce state-by-state and national emission estimates for GHG. The first such compilation for North Carolina was compiled for EPA by Appalachian State University[2, 3] in 1996 (for Calendar Year 1990). DAQ provided limited review of these data and we used them in this report.

Fuel Consumption in North Carolina

In NC, emissions from fossil-fuel combustion comprise the majority of GHG emissions. CO_2, resulting from the oxidation of the carbon in the fuel, is the predominant emission, in terms of mass or volume, from combustion processes (See Figure 2.1). Over 97% of the mass of GHG emissions attributable to combustion of fossil fuels is carbon dioxide.

Figure 2.1: Proportion of Greenhouse Gases from Combustion of Fossil Fuel in NC



[1] **Clean Air Act**; PL 101-549, 101st Congress, Washington, DC, November 15, 1990

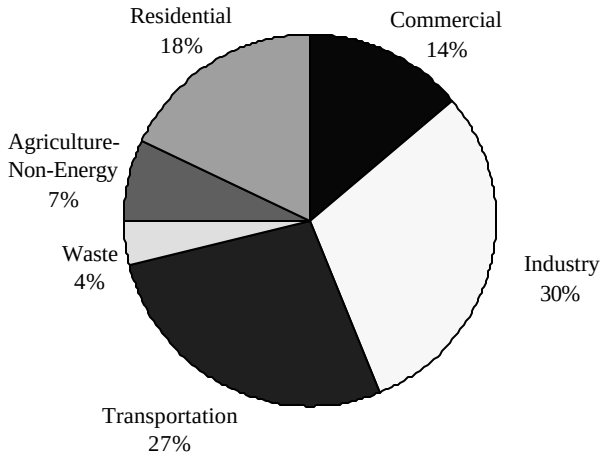
[2] Climate Change and North Carolina; US EPA, Climate and Policy Assessment Division, , EP 236-F-98-007q, September 1998.

[3] North Carolina's $ensible Greenhouse Gas Reduction $trategies Executive Summary; Appalachian State University, Department of Geography and Planning, Boone, NC, January 2000.

Emissions from fossil fuel combustion are related directly to the type and amount of fuel consumed, the efficiency with which the fuel is oxidized and the carbon content of the fuel. These relationships depend upon the amount of carbon contained in the fuel per unit of useful energy produced, which varies among different fuel types. For example, coal contains the highest amount of carbon per useful unit of energy, while petroleum and natural gas have about 80% and 55%, respectively, that of coal. In addition, due to inefficiencies in the combustion process, not all carbon in fuel products is oxidized to CO_2. Relatively minor amounts of carbon are incompletely oxidized to CO (carbon monoxide) which eventually is oxidized to CO_2 in the atmosphere or is removed by other sinks.

The Department of Geography and Planning at Appalachian State University generated a 1990 NC GHG emissions inventory.[1,2] Generating the GHG emissions inventory for 1990 was important because it established a baseline (consistent with the Kyoto Protocol) for strategic planning and it also identified areas where emission reductions can be targeted. Furthermore, the base year emissions inventory is integral in projecting future emissions because it serves as a baseline to compare the effectiveness of reduction strategies on future emissions inventories, and provides a sense of what sector of the economy is responsible for the use/emissions. Figure 2.2[3] provides a summary of the 1990 GHG emissions, by use sector, in North Carolina.

Figure 2.2 – North Carolina Greenhouse Gas Emissions in 1990 (with fossil-fueled utility electric generation allocated to sectors of the economy that used the electricity)



[1] North Carolina's $ensible Greenhouse Gas Reduction $trategies; Appalachian State University, Department of Geography and Planning, Boone, NC, January 2000.
[2] Climate Change and North Carolina'; EP 236-F-98-007q, EPA, Climate and Policy Assessment Division, September 1998.
[3] Ibid Reference 1

Commercial/Institutional Sector

The commercial/institutional sector includes a variety of buildings used by businesses, organizations, and government agencies, such as office buildings, hotels, multi-story apartments, beauty salons, bookstores, shopping malls, dry cleaners, lumber stores and school buildings. GHG emissions from the commercial/institutional sector come from energy for heating, cooling, lighting, domestic hot water, refrigeration, cooking, electronic equipment, and other similar operations. CO_2 emissions directly produced from combustion in this sector are approximately 49.4 % from natural gas; 42.2% from oil, 7% from coal and 1.5% from biomass.

CO_2 emissions from this sector totaled 3.7 million tons in 1990, only about 3% of the 120.9 million tons of CO_2 emissions that originated from fossil-fuel consumption in the state. Therefore, this sector is not the major (direct) generator of the carbon load being added to the atmosphere in NC, though they are a user of electric power and thus an indirect contributor.

Industrial/Manufacturing Sector

Direct emissions of CO_2 by the industrial/manufacturing sector in 1990 totaled 38.9 million tons from all carbon fuels, some 28.3% of the 137.4 million tons of CO_2 emitted due to combustion of all fuels in North Carolina. On a percentage basis, fuels utilized in the industrial/manufacturing sector are distributed among oil at 27.3%, coal at 19.4% and gas at 13.2%. Other fuels, primarily biomass (wood is commonly used as a fuel for many furniture and wood/paper product facilities), account for over 15 million tons of CO_2, or approximately 40% of the total.

NC Electric Production and Use

In North Carolina, coal, natural gas, light fuel oil, motor gas, diesel fuel, and propane account for nearly all of the CO_2 emissions. In 1990, electricity accounted for 59 million tons of CO_2 emissions. At 0.188 tons of CO_2 per million Btu, electric generation is the most GHG-intensive form of energy used in the state. Generation of electricity emits over twice as much CO_2 per unit of end use energy as gasoline and other petroleum products, and three times as much as the direct use of natural gas. Therefore, the utility sector is a key in any GHG reduction strategy.

The utilities sector produces electricity utilized by other sectors of the economy. As cited in *North Carolina's $ensible Greenhouse Gas Reduction $trategies*[1], the data used for 1990 allocated utility emissions to the end use sectors, specifically, industrial, commercial, residential, and agriculture. To prevent double counting of emissions attributable to the utilities sector, the report totaled the supply-side utilities emissions from the projected 2010 emissions totals, and subtracted the impact of all the electricity demand measures implemented in the end use sectors. Thus, it allows analysis of the impacts of strategies specific to the utilities sector.

North Carolina's energy demand is driven by the rapid growth in all sectors of the economy. The Virginia and Carolina Region of the Southern Electric Reliability Council

[1] North Carolina's $ensible Greenhouse Gas Reduction $trategies Executive Summary Appalachian State University, Department of Geography and Planning, Boone, NC, January 2000.

projected[1] peak load growths of 2.3% for both summer and winter peaks for 1995-2004. Furthermore, North Carolina's final electricity consumption in terms of kilowatt-hour (kWh) sales is evenly distributed between the residential (38.5%), commercial (28.3%), and industrial (32%) sectors. The state's electric demand growth is occurring in all three sectors.

In a "business-as-usual" forecast, these studies projected that electricity demand will likely grow to 512 trillion Btu by 2010, 31% higher than its 1990 level. The use of natural gas for power production was just beginning in 1990, but by 2010, it may grow to supply over 10% of the State's power. By 2010, the studies projected petroleum fueled power plants to grow to produce about 5% of the State's power.[2] Thus, electricity has experienced exponential growth.[3]

Figure 2.3:
Energy Use in Utility Sector

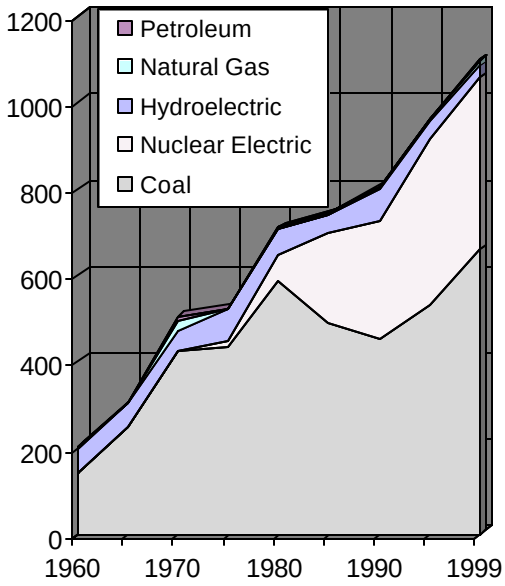


Figure 2.3 shows the trend for energy use in the electric utility sector. Coal has maintained and extended its historical dominance.

As shown in Table 2.1, coal-generated electricity currently provides about 60% of total electricity needs for North Carolina, nuclear power provides about 36%, hydroelectric plants supply 2.5%, and natural gas and petroleum supply 1% or less.

[1] North Carolina's $ensible Greenhouse Gas Reduction $trategies; Appalachian State University, Department of Geography and Planning, Boone, NC, January 2000.
[2] Ibid, Reference 1.
[3] The North Carolina Energy Plan (proposed), Chapter 3, http://www.ncenergy.appstate.edu/draft/index.php, June, 2003.

Table 2.1:Percentage of Total Electrical Production

	Coal	Natural Gas	Petroleum	Nuclear	Hydro
1960	71.1%	2.4%	0.2%	0.0%	26.3%
1965	80.7%	1.0%	0.1%	0.0%	18.2%
1970	84.5%	4.3%	2.2%	0.0%	9.1%
1975	82.6%	0.0%	0.4%	3.0%	14.0%
1980	82.4%	0.3%	0.5%	8.8%	8.0%
1985	65.8%	0.1%	0.3%	28.0%	5.7%
1990	56.1%	0.3%	0.3%	34.4%	9.0%
1991	53.5%	0.4%	0.2%	38.5%	7.4%
1992	62.9%	0.4%	0.2%	29.2%	7.3%
1993	64.8%	0.3%	0.2%	28.6%	6.1%
1994	55.7%	0.1%	0.3%	37.6%	6.3%
1995	55.4%	0.3%	0.2%	39.7%	4.3%
1996	60.3%	0.2%	0.3%	34.6%	4.5%
1997	63.0%	0.4%	0.3%	32.3%	4.0%
1998	58.5%	1.1%	0.3%	36.2%	3.7%
1999	60.0%	1.0%	0.3%	36.2%	2.5%

EXISTING COAL FIRED UTILITY CO_2 EMISSIONS

Coal combustion from the utility sector accounted for 45.9 million tons of CO_2 in 1990.[1] The quantities of other GHG emissions by utilities are relatively small. Emissions of carbon dioxide by specific fossil-fired power plants are shown in Table 2.2.

Table 2.2: CO_2 Emissions by Specific (CSA) Coal Fired Unit in North Carolina (tons)

Plant Name	1995	1996	1997	1998	1999	2000	2001
Asheville	2,939,767	3,055,829	2,558,792	2,518,633	2,866,123	3,003,068	2,730,256
Belews Creek	12,350,708	13,617,317	16,482,258	15,599,278	14,444,190	11,727,317	13,148,649
Buck	630,484	1,738,805	2,115,938	1,579,343	1,868,804	1,965,627	1,730,127
Cape Fear	1,599,350	1,873,205	1,681,188	1,813,330	1,681,385	1,664,803	1,535,760
Cliffside	2,784,386	3,847,189	3,746,374	4,341,770	3,827,848	4,167,193	4,049,227
Dan River	477,244	1,079,704	1,102,343	931,356	1,183,270	1,170,227	898,554
G G Allen	3,661,778	5,545,956	6,627,324	4,508,312	5,619,742	5,914,264	5,487,331
L V Sutton	1,971,796	2,731,810	2,416,051	3,090,303	2,937,714	2,911,009	2,678,861
Lee	994,751	1,489,375	1,701,086	1,991,169	2,034,902	2,497,634	2,438,866
Marshall	13,757,769	14,353,025	13,922,689	13,319,829	12,196,762	13,262,502	11,860,117
Mayo	5,035,618	3,953,151	5,529,689	5,156,271	5,105,715	5,827,689	5,211,732
Riverbend	395,414	2,098,651	1,987,603	1,888,967	1,781,849	2,666,624	2,374,459
Roxboro	14,220,431	14,554,168	14,775,907	15,425,770	16,092,702	15,575,045	14,983,859
Weatherspoon	313,653	663,004	777,718	854,583	859,787	939,474	845,393
Total	**61,211,611**	**70,771,537**	**75,645,953**	**73,625,012**	**72,975,847**	**74,058,731**	**70,821,909**

[1] The North Carolina Energy Plan (proposed), http://www.ncenergy.appstate.edu/draft/index.php , June, 2003.

A measure of relative CO_2 emission rate efficiency among power plants is the **CO_2 Emissions Rate** in pounds per Megawatt hour (lbs/MWh). This value for CSA-affected units is shown in Table 2.3, also adapted from the ASU reports previously cited.

Table 2.3: 1995 CO_2 Emissions Rate Data for NC's CSA Fossil Power Plants

Company	Plant Name	CO_2 Emissions Rate (lbs/MWh)
Duke		
	Bellews Creek	2,048
	Buck	2,537
	Cliffside	2,317
	Dan River	2,796
	GG Allen	2,186
	Marshall	2,182
	Riverbend	Not reported
Progress		
	Asheville	2,253
	Cape Fear	2,052
	HG Robinson	2,367
	LV Sutton	2,329
	Lee	2,306
	Mayo	2,479
	Roxboro	2,214
	Weatherspoon	2,498

PROPOSED CLEAN SMOKESTACKS CONTROLS BY PLANT

The CSA requires a level of system-wide controls for NOx and SOx, but does not specify any limits or specific control devices on specific plants. The management of that process is left to the utility to propose, based on technologies available, physical layout, costs and other plant-specific factors. The plants are required to keep DENR informed and will have to apply for specific permit changes in each instance. To date, both companies in NC that are effected by the requirements have provided lists of general types of devices that they are considering that will provide the reductions required (or better). These are still subject to some revisions as design, cost and other factors become more clearly defined and final decisions are made. Table 2.4 lists the proposed controls as of this writing[1], [2] and no major changes are expected. The addition of these controls will not have any significant effect on the collection and removal of CO_2 from the stacks of these units. Other options being researched to provide such controls and sequestration are discussed elsewhere in this report.

One point that should be noted is that the installations of the controls required by the CSA are not without a penalty as far as CO_2 is concerned. The added air moving and liquid

[1] George T. Everett, PhD., Duke Power, Letter to North Carolina Utilities Commission, Raleigh, NC, March 31, 2003.

[2] Len S. Anthony, Progress Energy, Letter to North Carolina Utilities Commission, Raleigh, NC, April 1, 2003.

moving equipment (fans and pumps) that are inherent in the controls to be installed, require energy, which must come from a reduction of the electric output of the unit (generally maximum fuel use and gross output are fixed and can not be increased). The unit cannot overcome these losses without basic process changes that may be discouraged under other current laws and regulations which will reduce the net electrical output of these units by about one percent.[1]

Table 2.4: Proposed Controls for Coal Fired Utility Units for Achieving the CSA Requirements

Company	Plant Name	Proposed Controls[2] [3]
Duke		
	Bellews Creek	**Unit 1**: SCR + SCRUB; **Unit 2**: SCR & LNB + SCRUB
	Buck	**Units 3-6**: SNCR
	Cliffside	**Units 1-5**: SNCR + SCRUB on **Unit 5**
	Dan River	**Units 1-2**: SNCR; **Unit 3**: SNCR & LNB
	GG Allen	**Units 1-5:** SNCR + SCRUB
	Marshall	**Units 1-4**: SNCR + SCRUB
	Riverbend	**Units 4 & 7**: SNCR; **Units 5-6**: SNCR & LNB
Progress		
	Asheville	**Unit 1**: LNB/AEFL/SCR+SCRUB; **Unit 2**: LNB/OFA/SCR+SCRUB
	Cape Fear	**Units5-6**: ROFA/ROTAMIX + SCRUB
	HG Robinson	None
	LV Sutton	**Unit 1**: SAS; **Unit 2**: ROFA; **Unit 3**: LNB/ROFA+SCRUB
	Lee	**Unit 1**: WIR; **Unit 2**: LNB/OFA/SCR; **Unit 3**: LNB/OFA/SCR+SCRUB
	Mayo	**Unit 1**: LNB/OFA/SCR+SCRUB
	Roxboro	**Units 1, 3-4**: LNB/OFA/SCR+SCRUB; **Unit 2**: TFS2000/SCR+SCRUB
	Weatherspoon	**Unit 3**: WIR

Terms used in this table are defined below:

AEFL- Amine-Enhanced Flue Lean Gas Reburn
LNB – Low NOx Burner
OFA – Overfire Air
ROFA – Rotating Opposed-Fired Air
ROTAMIX – Injection of Ammonia to further reduce NOx (Used in combination with ROFA)
SCR – Selective Catalytic Reduction
SCRUB – Wet scrubber for SOx
SNCR – Selective Non-Catalytic Reduction
TFS2000 – Combination Low-NOx Burner/Overfire Air
WIR- Underfire Air

[1] Personal (Oral) Communication from Cheryl Vetter with Progress Energy to James Southerland, NC DAQ, July 11, 2003.
[2] George T. Everett, PhD., Duke Power, Letter to North Carolina Utilities Commission, Raleigh, NC, March 31, 2003.
[3] fLen S. Anthony, Progress Energy, Letter to North Carolina Utilities Commission, Raleigh, NC, April 1, 2003.

Chapter 3 The Regulatory "Climate" Outside North Carolina

The discussions in this chapter are intended to put the North Carolina actions and planning regarding CO_2 emissions and reduction expectations in perspective with international and national actions, plans and uncertainties at the time of the writing of this document, especially with regard to other requirements that may be imposed externally.

Kyoto Treaty and its Predecessors

In an effort to reduce GHG (including CO_2) and mitigate their effects, the US has participated in several world conferences dealing with global climate change.[1] The most noteworthy of these conferences was probably the one held in Kyoto, Japan in 1997. At this meeting, most industrial countries of the world, including the US, agreed to lower their GHG production. Negotiators for the US agreed to reduce emissions by 7% below its 1990 emissions level between 2008 and 2012. However, this treaty was subject to Senate approval. The US Senate has yet to formally ratify or further validate the treaty and the Bush Administration has not been in support of the protocol. Instead, an alternate proposal has been made that provides for the U.S. to commit to a reduction in the rate at which the release of these gases is increasing. This proposal falls far short of the original target. Bush's Clear Skies Initiative (CSI-February 2002, aka Clear Skies Act): proposed to reduce GHG "intensity" by 18% by 2012, where "GHG intensity" is a measure of the ratio of GHG emissions to economic output. This proposal allows total emissions to rise with increasing economic activity, rather than through a cap on emissions as specified in Kyoto.

The text of the protocol to the United Nations Framework Convention on Climate Change (UNFCCC) was adopted at the third session of the Conference of the Parties to the UNFCCC in Kyoto, Japan, on December 11, 1997. The protocol is subject to ratification, acceptance, approval or accession by Parties to the Convention. It was open for signature from March 16, 1998 to March 15, 1999 at United Nations Headquarters in New York. By that date, the protocol had received 84 signatures. Those parties that have not yet signed the Kyoto Protocol may access it at any time at the UN Headquarters in New York. It was determined to enter into force on the ninetieth day after the date on which not less than 55 parties to the Convention signed Annex I. Parties that accounted in total for at least 55% of the total carbon dioxide emissions for 1990 from that group have deposited their instruments of ratification, acceptance, approval or accession. As of July 10, 2003, 84 Parties had signed and 111 Parties had ratified or acceded to the Kyoto Protocol[2], accounting for about 44.2% of the global GHG.

In March 2001, President Bush formally announced opposition to the Kyoto Protocol, and Congress reacted by proposing legislation supporting further positive action in the international negotiations on climate change. A budget resolution for fiscal year 2002 passed, including funds for US participation in further international climate change negotiations. Senator

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[1] North Carolina's $ensible Greenhouse Gas Reduction $trategies; Appalachian State University, Department of Geography and Planning, , Boone, NC, January 2000.

[2] Status of the Kyoto Protocol; The United Nations Framework Convention on Climate Change, http://unfccc.int/resource/convkp.html#kp, New York, NY, July 18, 2003.

John F. Kerry authored and proposed a non-binding resolution urging the US to put forth a proposal to secure US participation in a revised Kyoto Protocol or other future binding climate change agreements. An amended version of the Kerry resolution was included in the energy policy bill passed by the Senate, but have not yet received full Congressional approval.[1]

The President's fiscal year 2003 budget includes $555 million in clean energy tax incentives, as the first part of a $4.5 billion commitment over the next five years ($7.1 billion over the next 10 years) to address climate change. The budget also requests over $3 billion (a $1 billion increase above the baseline) as the first part of a ten-year (2002-2011) commitment to implement and improve the conservation title of the Farm Bill, which will significantly enhance the natural storage of carbon.

In a new policy announcement on July 24, 2003 the President unveiled a new five point plan for increased research.[2] This Climate Change Science Program Strategic Plan's stated primary goal is to identify "natural variability" in climate change. The second is to find better ways of measuring climate effects from burning fossil fuels, industrial production of warming gases and changes in land use. The other goals of this ten year program are to reduce uncertainty in climate forecasting; to better understand how changes in climate affect human, wildlife and plant communities; and to find more exact ways of calculating the risks of global warming. The administration also will ask Congress for a new $103 million, two-year initiative to speed up "high priority" research on carbon pollution, aerosols and oceans and determine the best ways to compile and disseminate information about them.

Current EPA and DOE Approaches & Registries

Since there are currently no federal legislation or standards requiring control of CO_2 emissions or the broader group of GHG, the reduction activities undertaken to date have been somewhat meandering and splintered. EPA has continued to focus on its traditional pollutant-by-pollutant rulemaking scheme, as required under the Clean Air Act (CAA) for other pollutants. The National Ambient Air Quality Standards (NAAQS) required in the CAA are implemented through a health or welfare effects "criteria" determination, with subsequent ambient standards specified. These are then normally implemented by delegation to state programs. There are also parts of the CAA that apply to hazardous air pollutants, which include mercury, but not CO_2. Efforts to implement this part of the CAA have produced drafts and plans on mercury, but no indication that any efforts are likely to require or develop mandatory controls on CO_2/GHG's. The efforts, however, to build the case for reductions have continued; and tools, registries, promotion programs and other similar efforts have generated a large amount of activity and concerns.

Debate over potential limits on emissions has demonstrated conflicting, or at least not fully harmonious, views from the EPA and the DOE.[3] In July 2002, the EPA signaled that it

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[1] Summary of National Climate Change Programs; California Energy Commission; http://www.energy.ca.gov/global_climate_change/summary.html, July 2003.

[2] John Marburger, Climate Change Science Program Strategic Plan Announcement; Office of Science and Technology Policy, Executive Office of the President, Washington, DC, July 24, 2003.

[3] "*US gov't reports set stage for multi-pollutant debate*"; Reuters, http://www.planetark.org/dailynewsstory.cfm/newsid/12637/story.htm, June 6, 2003.

might replace current regulations with a new cap-and-trade system for NOx, sulfur dioxide and mercury, but this move did not include CO_2. That approach would allow power plants to buy emission rights from cleaner plants. DOE has opposed EPA's actions, presumably because they feel this might hamper US utilities from boosting electricity output.

Section 1605(b) of the Energy Policy Act of 1992 [42 U.S.C. ¤13385] established the **Voluntary Reporting of Greenhouse Gases Program**, which allows and encourages sources to report GHG reductions. Currently, both DOE and EPA have GHG registries. Registries are a first step in reduction strategies and mandatory for banking-and-trading scenarios. The DOE 1605(b) registry is the closest to a US-wide registry. North Carolina has been a leader in the efforts to register (39) industries within the state in that registry. However, EPA also has a registry that promotes the reporting of emissions and the adoption of agreements to reduce emissions. On the other hand, EPA's registry is primarily viewed as a means of tracking its own success in encouraging reductions of emissions only. Currently there is no mechanism, nor does there appear to be significant serious movement, to join or "seamlessly" relate one of these registries to the other. Major announcements from DOE regarding their registry and reporting mechanisms are overdue and expected "any day."

Under the US Senate-passed (only) Energy Policy Act in April of 2002, reporting of GHG emissions would be voluntary, at first. After five years, however, if fewer than 60 percent of the US GHG emissions were not reported under the program, it would become mandatory for the largest emitters. This bill has not become law. Steps to refine existing federal registries to make them more transparent and uniform will be necessary to facilitate reductions in GHG by cap-and-trade programs that appear to be gaining momentum. Ideally, standardized reporting should consolidate these tools and make them more useful for all purposes, including any cap-and-trade programs.

Activity in many of these continues, but remain uncertain. It would appear appropriate for NC to support and encourage, along with other states, a single and clearly defined registry. This would be supported by most other states, emission trading organizations, industry and the international community.

Federal Multi Pollutant Bills

In the past 25-30 years, various reduction strategies have been developed and promoted, registries implemented, and research carried out, but no significant and specific federal mandates currently exist to control CO_2 or other GHG in the United States. Efforts to formalize and finalize subscription to international treaties and agreements related to international registries and tracking of GHG are incomplete. Rumors and speculated intentions continue to appear, but decisive action is slow in coming.

CLEAR SKIES INITIATIVE

The Bush Administration has proposed a CSI,[1] as previously mentioned, that is awaiting Congressional action. In the meanwhile, other bills are active to some degree in both the US

[1] Clear Skies Act of 2003 Fact Sheet: *Cleaner Air, Better Health, Brighter Future;* EPA, Following President George W. Bush, State of the Union, Washington, DC, January 28, 2003.

House and Senate. There has been considerable debate whether any legislation would be three-pollutant (SOx, NOx and Mercury) or four-pollutant (add CO_2). The main legislative initiatives to date, in addition to the CSI, are the Jeffords-Waxman Bills and the Carper Clean Air Planning Act (CAPA - S3135). None of the bills introduced to date have made significant progress toward full consideration by the Senate and House, though committee testimony, debate and behind-the-scene efforts remain quite active. It is reasonable to speculate that actual legislation will not be voted upon until after the next Presidential election. The discussion below does not encompass all actions and discussions underway, but to provide some major points.

JEFFORDS-WAXMAN BILLS

The Senate Environment and Public Works Committee has held several hearings to date, and in June of 2002, narrowly passed the "Clean Power Act"[1] (S.556 or "CPA") proposed by Sen. James Jeffords. The House companion bill, Henry Waxman's "Clean Smokestacks Act" (H.R. 1256), has not passed in committee or on the House floor. As a matter of measure, the Senate rejected the climate change provisions of the 2002 Senate Energy Bill by a margin of 15 to 1. The final CPA, if passed as generally proposed, would establish new controls on power plant emissions of sulfur dioxide (SO_2), nitrogen oxides (NOx), mercury and carbon dioxide (CO_2). The bill would make the Kyoto agenda a central focus of U.S. energy policy. Opponents say that these bills would "abandon that common-sense approach and attempt to reduce pollution indirectly," by suppressing energy use.

CARPER BILL

The Carper Bill, also known as the Clean Air Planning Act [2] (CAPA S.3135) was introduced by Sen. Thomas Carper during the last days of the 107th Congress. Primarily, it was authored because the CSI and CPA were so far apart. Although, the proposal was a bipartisan effort, it has not yet received full consideration in either Committee, much less the full Senate.

Probably these bills will become the subject of debate during upcoming elections and perhaps will wither for the time being and reintroduced after the elections are completed.

Activities in Various States

A majority of the states has initiated some kind of efforts independent of, or in conjunction with, the federal efforts. North Carolina has been primarily involved through the DOE registry and related "**Climate Wise**" program and somewhat indirectly through its actions on the research of ways to convert animal waste into a viable energy source. The summary below was compiled from several state and national web sites and other information sources and may not be complete or entirely up to date. The list of activities covers a wide variety of activities ranging from direct climate change strategies/actions to others that could be better characterized as only indirectly oriented toward climate change.

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[1] Jeffords Introduces Clean Power Act of 2003, U.S. Senate , Washington, D.C., http://www.senate.gov/~epw/Releases/release_02-12-03.htm, and http://epw.senate.gov/maj_pr_062702b.htm, 2003.

[2] Introduction, Clean Air Planning Act; **Congressional Record,** U.S. Senate, http://carper.senate.gov/acrobat%20files/FS101702.pdf ; October 17, 2002.

According to a California DOE summary[1], GHG inventories have been completed in thirty-seven states, with four more in progress. Nineteen states have completed action plans to reduce GHG emissions, with eight more in progress. Twelve states have established renewable portfolio standards. Several states are developing voluntary registries for GHG emissions and the picture is changing rapidly so it is hard to keep exactly up to date.

CALIFORNIA

On July 10, 2002, California passed a bill[2] that requires reductions in automobile tailpipe emissions of carbon dioxide and other greenhouse gases. What this means simply is that they must burn less fuel. The initial California tailpipe emissions proposal was heavily opposed by a coalition led by automakers and their unions that had previously killed higher fuel efficiency standards in the US Congress. This coalition claimed that the bill's purpose was to run SUVs off the roads. The bill's primary sponsor modified the legislation to deal with these arguments, and required that California air regulators balance the benefits of emission reductions with the costs of building more fuel-efficient cars. It prohibits bans on the use of SUVs or any other specific vehicles. More than 80 percent of California residents support global warming pollution cuts, according to a poll by the non-partisan Public Policy Institute of California[3]. This new law (AB 1493) requires the California Air Resources Board to design policies to "achieve the maximum feasible reduction of greenhouse gases" from cars and trucks by 2005. New regulations would first apply to the 2009 vehicle model year. This law prohibits new taxes and provides for legislative review before new regulations go into effect.

California has also been a leader in GHG registries. The **California Climate Action Registry** (the Registry) was established by California statute as a non-profit voluntary registry for GHG emissions. The purpose of the Registry is to help companies and organizations with operations in the state to establish GHG emissions baselines against which any future GHG emission reduction requirements may be applied. The Registry[4] encourages voluntary actions to increase energy efficiency and decrease GHG emissions. Using any year from 1990 forward as a base year, participants can record their GHG emissions inventory. The State of California, in turn, will offer its best efforts to ensure that participants receive appropriate consideration for early actions in the event of any future state, federal or international GHG regulatory scheme. Registry participants include businesses, non-profit organizations, municipalities, state agencies, and other entities. California remains a leader in GHG actions, especially for motor vehicles and GHG registry development.

Connecticut is a participant in the July 2003 coalition of Northeastern states. For more details, see discussion on New York below.

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[1] Summary of National Climate Change Programs; California Energy Commission; http://www.energy.ca.gov/global_climate_change/summary.html, July 2003.

[2] **New Democrat Online**; http://www.ndol.org/ndol_ci.cfm?contentid=250635&kaid=131&subid=192; July 8, 2002.

[3] Natural Resources Defense Council; http://www.nrdc.org/media/pressreleases/020722.asp; July 2003.

[4] California Climate Action Registry; http://198.104.131.213/Default.aspx?tabid=3393&refreshed=true; July 2003.

Delaware is a participant in the July 2003 coalition of Northeastern states. For more details, see discussion on New York below.

GEORGIA

Georgia has a **No-Tillage Assistance Program**. This program leases "no-till" equipment to farmers, thereby reducing fuel use compared to conventional tilling techniques. Since 1987, the program is credited with saving over 2.7 million gallons of fuel to avoid an estimated 25,000 tons of CO_2.[1]

ILLINOIS

The Illinois' **Clean Energy Community Trust** provides grants, loans, and other financial incentives to develop, improve, and implement energy efficiency and renewable energy projects and programs.[2]

INDIANA

The state's **Public Facility Energy Efficiency Program** provides loans from the Indiana Efficiency Loan Fund to help schools, political subdivisions and public libraries identify and/or implement energy projects. The state also provides grants to businesses, non-profits, and local governments to cover the incremental cost of renewable energy projects. The **Alternative Fuel Vehicle Infrastructure Grant Program** provides grants on a competitive basis to encourage the building of alternative fueling sites.[3]

IOWA

This state's **Building Energy Management Program** (1989) enables Iowa schools, local governments, and hospitals to implement cost-effective energy management programs without incurring up-front costs. In 2001, over 500,000 tons of CO_2 emissions were avoided through the program. Iowa recently developed 2 major wind farms, which together will avoid more than 700,000 tons of CO2 emissions annually. The state's Department of Natural Resources provides support, funding, and information to promote switch grass as a biomass energy crop. Iowa plans to get 10% of its energy from renewable sources by 2015.[4]

KANSAS

Kansas provides income tax credits for the purchase of alternative-fuel vehicles.[5]

MAINE

Maine has adopted renewable portfolio standards (RPS) that set a target for renewable energy as a proportion of the overall electricity fuel mix. They are developing a voluntary

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[1] Summary of National Climate Change Programs; California Energy Commission; http://www.energy.ca.gov/global_climate_change/summary.html, July 2003.
[2] Ibid Reference 2
[3] Summary of National Climate Change Programs; California Energy Commission, http://www.energy.ca.gov/global_climate_change/summary.html; July 2003.
[4] Ibid Reference 1
[5] Ibid Reference 1

registry for GHG emissions. The state is also a participant in the July 2003 coalition of Northeastern states formed for addressing the climate issues. For more details, see discussion on New York below.

MARYLAND

Maryland provides income tax credits for the production and sale of electric power from biomass combustion. They also provide tax incentives for purchases and investments in clean energy technologies and consumer products. The governor has released an **Executive Order** requiring state facilities to purchase a percentage of energy from "green" sources, evaluate energy efficiency in state building design and maintenance, and purchase **Energy Star**-labeled products when available.

MASSACHUSETTS

In April 2001, Massachusetts capped CO_2 emissions from its 6 highest-emitting power plants and created an emission standard that will require CO_2 reductions of about 10% below the current average emission rate. This regulation allows companies to buy carbon credits to meet the reduction requirements[1]. The state is also a participant in the July 2003 coalition of Northeastern states formed for addressing the climate issues. For more details, see discussion on New York below.

MISSOURI

Missouri provides schools and local governments with technology and financial assistance to implement energy-efficient upgrades. In 2000, the program claimed to have reduced CO_2 emissions by about 10,000 tons.

MONTANA

Their **Universal Systems Benefit Program** requires all electric and natural gas utilities within the state to collect funds from their customers, to be redistributed to offer individuals, organizations, and business support for energy efficiency improvements.[2]

NEW HAMPSHIRE

The **New Hampshire Clean Power Strategy** (**NHCPS**)[3] was developed to address

- Risks to NH's environment and public health associated with power plant emissions
- Opportunities for taking advantage of an integrated approach for control of multiple pollutants SO_2, NOx, mercury, and CO_2 , and
- NH Legislature's expectations for environmental improvement under electric deregulation.

The **NHCPS** applies to all existing fossil fuel-burning power plants with a capacity of 25 MW or greater, the same applicability threshold used by EPA's NOx SIP Call. The CO_2

[1] Ibid Reference 1

[2] Summary of National Climate Change Programs; California Energy Commission; http://www.energy.ca.gov/global_climate_change/summary.html; July 2003.

[3] Danuta Andzelm, The New Hampshire Clean Power Strategy: A Review; http://www3.gov.ab.ca/env/air/emissions_trading/pdf/newhampshire.pdf, Alberta Environment, June 2002.

emission limit originally included a 7% reduction below 1990 levels. This was modified by the Legislature to equal the 1990 levels due to economic considerations.

The state has also indicated its intention to be a participant in the July 2003 coalition of Northeastern states formed for addressing the climate issues. For more details, see discussion on New York below.

NEW JERSEY

A Governor's **Executive Order** to reduce the state's annual GHG emissions to 3.5% below 1990 levels by 2005 is in place. The state's emissions reduction plan includes a combination of voluntary actions and state initiatives. Their **Sustainability Greenhouse Gas Action Plan (2000)** includes policies and technologies on which the potential emission reductions are based. In addition, a mandatory statewide recycling program is in place, through which the state avoided 8.7 million tons of GHG emissions from 1990 through 1995. The state is also developing a voluntary registry for GHG emissions[1, 2]

The state is also a participant in the July 2003 coalition of Northeastern states formed for addressing the climate issues. For more details, see discussion on New York below.

NEW YORK

New York has developed a **New York GHG Task Force**. This group has studied the means for the state to make reductions and recently made recommendations to reduce GHG in the state. On May 8, 2003, they submitted a report to Governor Pataki with 27 recommendations for reducing GHG emissions. Their recommendations include:

- Establishing a state GHG emission reduction target of 5% below 1990 levels by 2010 and 10% below 1990 levels by 2020;
- Creating a program to limit emissions from electricity generation to levels 25% below 1990 levels by 2010, and making this cap part of a regionally coordinated policy with each state adopting its own cap;
- Redirecting state transportation funds to transit, walking and bicycling;
- Adopting California's GHG motor vehicle emission standards for model year 2009;
- Establishing a comprehensive GHG inventory, with mandatory reporting by major industries and sectors and a voluntary emission reductions registry; and
- Negotiating voluntary reduction agreements with industry.

New York has begun to implement some of the Task Force recommendations[3]. Governor Pataki announced in January 2003 that New York would adopt California's GHG motor vehicle emission standard and a "Renewable Portfolio Standard" so that 25% of electricity purchased in the state would come from renewable sources. In June 2003, the New York State Energy

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[1] NESCAUM State Comparison Matrix; http://www.nescaum.org/Greenhouse/Registry/state_matrix.html, July 2003.

[2] Summary of National Climate Change Programs; California Energy Commission, http://www.energy.ca.gov/global_climate_change/summary.html; July 2003.

[3] Greenhouse Gas State Registry Collaborative; NESCAUM, http://www.nescaum.org/Greenhouse/Registry/state_matrix.html ,July 2003.

Planning Board adopted the Task Force's recommendations for a GHG emission reduction target and to redirect transportation funding.

In **Phase II**, participants will tackle a number of projects aimed at advancing two primary project objectives: (1) public education and outreach and (2) building consensus on broader policy issues. These projects include,

- Expand the case studies to other entities (e.g., state and municipal authorities; hospitals, universities, etc.) and types of sources (e.g. manufacturing, pharmaceuticals, etc.),
- Develop a small-business outreach component that links large private-sector participants with their upstream and downstream business partners to explore untapped emission reduction opportunities and build political support for action within a crucial new stakeholder constituency,
- Examine baseline scenarios for pre-2000 reduction activities, with the aim of developing proposals to ensure baseline protection for entities that act early to reduce GHG emissions,
- Develop a model, regional GHG emission reduction registry that can provide guidance on methodological issues in documenting reductions and bring consistency to individual states' efforts to create early action registries, and
- Review the DOE Energy Information Agency's 1605(b) voluntary registry submissions, assess the "real" reductions represented by these actions taking into account entity-wide emissions, and develop criteria for recognizing early actions in the context of a future regulatory program.

On July 27, 2003, New York announced an additional agreement[1] that brings nine northeast states together to develop a regional strategy of actions on climate change. This coalition of states will work together to develop a market-based emissions trading system to reduce emissions from power plants. The states that have agreed to take part in this initiative include New York, Connecticut, Vermont, New Hampshire, Delaware, Maine, New Jersey, Pennsylvania, Massachusetts, and Rhode Island.

OREGON

Oregon bills its **CO_2 Policy and Legislation** as the first CO_2 regulatory standard in the US.[2] It regulates CO_2 by

- Requiring new power plants and other large energy facilities to avoid or offset a significant portion of their CO_2 emissions
- Encourages the developers to build the most efficient power plant possible,
- Provides Developer Options,
- Creates several methods for meeting the CO_2 standard, including providing funds to an independent trust to implement CO_2 offsets, and

[1] "Environmental Defense Applauds Pataki Multi-State Climate Effort" (News Release) http://www.environmentaldefense.org/pressrelease.cfm?ContentID=2910 Environmental Defense Fund, Washington, D.C., July 24, 2003.

[2] Mike Burnett, Innovative Policy for Greenfield Greenhouse Gas Emissions; Oregon Climate Trust, http://www.cultural.org/ace/pt/pres/burnett/tsld002.htm, November 1999

- Provides for an Evolving Standard: The Energy Facility Siting Council can reset and tighten the allowable limits over time.

The Legislation Provides that:

- New gas-fired power plant CO_2 emissions rate limits for gas fired plants
- Includes a mechanism for EFSC to tighten the CO_2 standard as power plant efficiency improves
- Standard is tied to a rate of 17% less CO_2 emissions than the most efficient power plant nationwide.

Pennsylvania is a participant in the coalition of Northeastern states formed in July 2003 for addressing the climate issues in the northeastern states For more details, see discussion on New York above.

Rhode Island is a participant in the coalition of Northeastern states formed in July 2003 for addressing the climate issues in the northeastern states For more details, see discussion on New York above.

TEXAS

The **Texas Loan STAR Program** provides energy efficiency project financing for state agencies, institutions of higher education, school districts, and local governments. A new **Renewable Portfolio Standard** requires that all electricity providers obtain renewable energy capacity, finance construction of renewable energy facilities, and develop new renewable energy resources by 2009. Energy producers can meet the standard by developing renewable energy capacity or by purchasing renewable energy credits.[1]

UTAH

Utah actions have resulted in the financing and installation of solar energy and energy efficient technologies in many of its state and national parks and monuments to reduce pollution in pristine areas and educate visitors about clean energy.

VERMONT

Vermont's stated goal is to reduce region wide greenhouse gas emissions, by state government, from the 1990 baseline by: 25% by 2012; 50;% by 2028; and, if practicable using reasonable efforts, 75% percent by 2050. An **Executive Order** signed in August 2002 by Governor Harold Dean MD[2] requires:

- A working group tasked with coordinating, documenting, and encouraging efforts to meet Vermont's greenhouse gas emission reduction goals. It prepares a biennial report

[1] Summary of National Climate Change Programs; California Energy Commission, http://www.energy.ca.gov/global_climate_change/summary.html; July 2003

[2] Harold Dean MD; Executive Order 11-02; State of Vermont Executive Department; http://www.anr.state.vt.us/dec/wastediv/csc/execorder.pdf; August 2002.

documenting these efforts, identifies future steps, their anticipated impacts, challenges for meeting the goals, and opportunities for expediting greenhouse gas emission reductions.

- Directs all state government agencies, offices, and departments to:
  - Purchase only energy-consuming devices that meet or exceed the **Energy Star®** or comparable standards established by the U.S. federal government;
  - Purchase vehicles that have the highest available fuel efficiency in each respective vehicle class;
  - Develop programs to encourage state employees, through the use of incentives, to use transportation alternatives to a single person in a single motor vehicle for travel;
  - Ensure that every state building reduces its energy consumption to meet the outlined greenhouse gas reductions;
  - The Department of Buildings and General Services must investigate cost-effective opportunities to purchase renewable energy to reduce the state's reliance on fossil fuels; including electricity derived from solar, wind, geothermal, landfill methane gas, or small scale (less than 30 megawatts) hydroelectric projects.
  - The Working Group must prepare a report to the Governor and the General Assembly describing opportunities to initiate a statewide voluntary greenhouse gas emissions registry, and investigate the feasibility of a carbon emissions cap and trading program for the state as a strategy for further reducing region-wide greenhouse gas emissions.
  - The order also requires the establishment of sector-specific baselines, development of an emission tracking protocol, and institution of an emissions trading mechanism.
  - The Group must also recommend further greenhouse gas reduction targets and identify activities to help meet those targets.

The state is also a participant in the July 2003 coalition of Northeastern states formed for addressing the climate issues. For more details, see discussion on New York above.

WASHINGTON

Washington has achieved reductions in electricity use through "demand site management," requiring electric utilities to control electricity demand. In addition, electric generating facilities powered by renewable resources are eligible for certain tax exemptions. Their **Commute Trip Reduction Program** (1991) includes state assistance and requires employers with over 100 employees (in 9 counties) to develop programs to encourage use of mass transit, carpooling, etc.[1]

WISCONSIN

Wisconsin assists one of its largest dairy farms with manure-to-energy technology. The state has developed a voluntary registry for GHG emissions.

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[1] Summary of National Climate Change Programs; California Energy Commission, http://www.energy.ca.gov/global_climate_change/summary.html; July 2003.

WYOMING

Wyoming recently established an advisory committee to implement a carbon sequestration and carbon credit-marketing program[1].

Groups of States and Other Jurisdictions

NESCAUM

The Northeast States for Coordinated Air Use Management (NESCAUM), a planning organization with membership from six New England States plus New York and New Jersey, has been active in the analysis and promotion of many issues related to GHG's. It has initiated a GHG demonstration project, which is now into Phase II. During the first phase of the project, participants quantified the effect of companies' specific GHG-reducing activities and began to explore broader issues related to the eventual treatment of these voluntary actions in the context of a future regulatory regime. Through this process, it demonstrated the availability of cost-effective and quantifiable GHG reduction opportunities in a host of industrial, residential, and transportation applications.

Nine GHG reduction projects were submitted to the **NESCAUM GHG Trading Demonstration Project** during **Phase I**:

- Tumbler front load clothes washers, an energy efficiency project submitted by the Northeast Energy Efficiency Partnership, Inc,
- A power plant fuel switch to natural gas submitted by PG&E Generation,
- Hydroelectric electricity production submitted by Ontario Hydro Generation (CHI Energy, Inc./North American Carbon Inc.),
- Landfill gas energy project submitted by PG&E Generation,
- Residential boiler conversions to natural gas submitted by KeySpan Energy,
- Battery operated shuttle buses submitted by the Northeast Alternative Vehicle Consortium,
    - Fuel cell energy production submitted by KeySpan Energy,
    - A waste heat project submitted by Sunoco, and
    - Biomass fueled electricity production project submitted by PSEG Global.

The NESCAUM web site has more details.[2]

NESCAUM has also begun utilizing new funding for developing a registry. Their stated aim is to "develop a voluntary registry with rigorous reporting and certification standards that could underwrite an emissions crediting and trading system(s) in the future, focusing initially on the power sector, and to have it enter operation within 18 to 24 months of the project's start." They plan to partner with the California Climate Action Registry and with the World Resources Institute, both of which have significant experience and expertise on GHG measurement and reporting. They also plan to make the NE registry compatible with the California registry so that companies can report to both using the same guidelines for quantifying emissions and certifying their reports. They have designed the project to fulfill the directive for a regional registry in the NEG/ECP action plan and to meet the parallel interests of New York and New Jersey under their

[1] Ibid Reference 1

[2] Overview of the NESCAUM Greenhouse Gas Early Action Demonstration Project: Phase II, http://www.nescaum.org/Greenhouse/index.html, NESCAUM, July 2003.

respective climate change agendas. However, they have also are invited other interested states to participate.[1]

NEW ENGLAND STATES AND EASTERN CANADIAN PROVINCES

In August of 2001, the New England Governors and the Eastern Canadian Premiers (NEG-ECP) signed an agreement for a comprehensive regional **Climate Change Action Plan** to jointly reduce regional GHG emissions. The Plan seeks to reduce regional GHG emissions to 1990 levels by 2010, reduce emissions by 10% below 1990 levels by 2020, and eventually reduce emissions sufficiently to eliminate any dangerous threat to the climate (75-85% below current levels). It also calls for a regional standardized GHG emissions inventory and registry. The plan includes measures to adapt regional economies and infrastructure to the negative impacts predicted to result from climate change[2].

As indicated in discussions above, on July 27, 2003 New York's Governor announced[3] an agreement that brings nine northeast states together to develop a regional strategy of actions on climate change. This coalition of states will work together to develop a market-based emissions trading system to reduce emissions from power plants. The states that have agreed to take part in this initiative include; New York, Connecticut, Vermont, New Hampshire, Delaware, Maine, New Jersey, Pennsylvania, Massachusetts, and Rhode Island. Together with full implementation of the earlier commitment in New York for mobile sources, a regional cap on power plant emissions is expected to achieve a goal of showing how practical, market-based tools can create a multi-sector solution to climate change.

Northeastern States Suit to List CO_2 as a Criteria Pollutant

Attorneys General from the states of Connecticut, Maine and Massachusetts recently filed suit June 4, 2003 in federal district court in Connecticut against EPA for its "failure to regulate carbon dioxide (CO_2) under the Clean Air Act." According to the lawsuit[4], EPA has acknowledged both that CO_2 emissions pose a serious risk to human health and that it has authority to regulate CO_2 emissions under the Clean Air Act. Accordingly, the suit contends that EPA has a mandatory duty to regulate CO_2 emissions under the Clean Air Act. If the lawsuit is successful, EPA will likely have to list CO_2 as a criteria pollutant and develop a national ambient air quality standard for it. Such a process would no doubt be lengthy (10-20 years before implementation) and would require development of a new process for "indirect" health effects.

Perhaps as a preemptive action, directly as a response to a petition and because of other internal decisions related to 5-year reviews required for criteria pollutants, EPA on August 27,

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[1] Jennifer Weeks, Senior Policy Analyst, NESCAUM, email dated July 21, 2003.

[2] Summary of National Climate Change Programs; California Energy Commission http://www.energy.ca.gov/global_climate_change/summary.html, July 2003.

[3] "Environmental Defense Applauds Pataki Multi-State Climate Effort" (News Release) http://www.environmentaldefense.org/pressrelease.cfm?ContentID=2910 Environmental Defense Fund, Washington, D.C., July 24, 2003.

[4] Commonwealth of Massachusetts, State of Connecticut, and State of Maine, Civil Action v. Christine Todd Whitman, Defendant, in her capacity as Administrator of the United States Environmental Protection Agency, United States District Court, District of Connecticut, June 4, 2003.

2003 announced a ruling[1] in the Federal Register on the status of CO_2 as an air pollutant for purposes of regulating motor vehicles and declared that it was not a criteria air pollutant. The announcement did however, reinforce other continuing climate change programs such as **Climate Leaders**, **Energy Star**, **Green Power**, **Smart Way** and **Best Workplaces for Commuters**. This action is independent of the court actions mentioned above, though there may be a bearing one on the other. It is likely to be a few months before the court rules on this suit.

[1] "EPA Denies Petition to Regulate Greenhouse Gas Emissions from Motor Vehicles," http://www.epa.gov/newsroom/headline_082803.htm; US EPA, Washington, D.C., August 28, 2003.

Chapter 4 Technical and Policy Options for Further Study

Various technical and policy options have been proposed in various studies and reports to provide answers to CO_2 emissions from the utility sector. Some such proposals may turn out to be practical and worthy of implementation and some proposals are continuing to be under development and research or have serious economic downsides that preclude their implementation in the near future. Some such options may have the appearance of providing a cure for the "problem" but with more in depth consideration, may be impractical or impossible.

The purpose of this chapter of the report is to identify some of these candidates for further study and to provide some insights into how future reports and considerations in NC may lead to rejection or eventual adoption of those that are advantageous for the state. Generally, these policies and technologies fall into:

1) Direct utility sector improvements in efficiency or methods of operation that result in more electricity for equal or less fuel,
2) Development and/or implementation of means to remove and directly sequester GHG before they enter the atmosphere,
3) New customer improvements in efficiency and the like to reduce power requirements and subsequently the GHG emissions at the utility plants,
4) New replacement energy generation technologies that generate less (or no) GHG and
5) Means to improve the sequestration and removal of emissions that have already entered the atmosphere.

Direct Utility Sector Improvement Opportunities

In this category, one must consider how to reduce emissions prior to their generation or to collect them after generation. As is often the case, efficiency and economics are key factors. The seriousness of the requirements, the practicality and viability of the solutions and the economic plausibility must be evaluated and traded off with regard to other impacts.

DIRECT POWER PLANT EFFICIENCY IMPROVEMENTS

Since the majority of CO_2 emissions from the electric industry (especially in NC) are from coal-fired power plants, attention must be given to evaluating possible methods for reducing emissions directly from these facilities. These options might include:

- Fuel Switching[1]
- Gasified Coal
- Increased Use of Oil and Gas Turbines[2]
- Combustion Modification
- Distributed Generation
- Others

[1] *Reducing Greenhouse Gases & Air Pollution: A Menu of Harmonized Options;* State and Territorial Air Pollution Program Administrators / Association of Local Air Pollution Control Officials (STAPPA / ALAPCO), Washington, DC, October 1999.

[2] R.W. Smith, et. al.; Advanced Technology Combined Cycles, GER-3936A, GE Power Systems; May 2001.

Potential Options from STAPPA/ALAPCO Study and Caveats

Table 4.1 is adapted from the cited STAPPA/ALAPCO study.[1] It summarizes technology-based options that may be worthy of further analysis during this study. Theoretical merits of these options may be evaluated for application to the NC plant "fleet." However, DAQ recognizes that such analyses must be undertaken in the context of economics and physical practicality and the current complex regulatory scheme. Fluidized-bed combustion, for example is probably an excellent high-efficiency means to improve the overall plant fleet. However, application of this technology would involve a substantially new plant and complication of the regulatory situation that now exists. One must assume that while the utilities in the business to generate electricity, they also need to make a profit and likely have already considered many options to increase efficiency and thus profitability. Evaluation of such barriers encountered in modifications may be worthy of further analysis.

Table 4.1: Summary of Potential Technology-Based Utility Emission Reduction Strategies

Technology-Based Strategy	Description
Combined Heat and Power	The combined heat and power process generates electricity and useful heat or steam in the same process. Cogeneration begins with either electricity or steam production. Excess energy from the first process is the input to the second.
Gas-Fired Combined Cycle	Combined cycle technology uses fossil fuel combustion to drive a combustion turbine. The waste hear from this process is then captured to drive a conventional steam generator with thermal efficiencies to 60% versus "the 30's" for conventional units.
Co-Firing with Biomass and Gas	Co-firing is the simultaneous combustion of coal and biomass or coal and natural gas in a previously coal-fired boiler. The process reduces both SO_2 and CO_2 emissions.
Integrated Gasification Combined Cycle	This process is the combustion of gasified coal in a combined-cycle system. A major benefit of coal gasification is that is allows many of the impurities in coal to be removed, providing considerable reductions in criteria pollutant emissions in relation to conventional coal combustion.
Fluidized-Bed Combustion	Combustion of crushed coal in a suspended mass within the boiler results in increased combustion efficiency and lower combustion temperatures relative to conventional coal boilers.
Fuel Cells	Fuel cells generate electricity and heat in an electrochemical reaction, as opposed to combustion.
Carbon-Sensitive Plant Dispatch	This plan promotes the operation of more low-emitting plants less high-emitting plants.

[1] Reducing Greenhouse Gases & Air Pollution: A Menu of Harmonized Options; State and Territorial Air Pollution Program Administrators/Association of Local Air Pollution Control Officials (STAPPA/ALAPCO), Washington, DC, October 1999.

POLICY-BASED OPTIONS TARGETED AT DIRECT REDUCTIONS

In addition to the aforementioned technology-based strategies to apply directly to coal fired power systems, there are policy-based strategies that should be evaluated and further considered. Such changes would be targeted at direct reductions before the emissions are produced, such as regulation of carbon emissions (carbon tax). Table 4.2 summarizes some policy-based strategies that were suggested in the study and report cited earlier.[1]

Table 4.2: Potential Policy-Based Utility Emission Reduction Strategies

Policy-Based Strategies	Description
Comparable Emission Standards	These standards would require old plants, formerly "grand fathered," to comply with tighter regulatory policies.
Output-Based Emission Standards	This system would establish emission standards in terms of mass per unit of electrical output, rather than per unit of heat output.
Tax Credits	Shift state and federal fiscal policy toward the support of lower-carbon generating technologies (similar to "Green Power Program.")
Environmental Disclosure	Disclosure laws would require all electricity suppliers to identify the environmental impacts of the electricity they are selling.
State-Level Emission Portfolio Standards	This program would require all retail electricity suppliers in a state to acquire power from sources that were at or below designated emission rates.
Anticipating Nuclear Retirements	This plan involves assessing the viability of existing nuclear plants and planning for their retirement or refurbishment.
Interconnection Policy	This policy would improve rules for interconnecting small generators with electricity distribution systems to facilitate interconnection and maintain the safety and reliability of the system.
Carbon Requirements in the Plant Siting Process	This plan would require developers of new power plants to offset future carbon emissions with investments in sequestration projects or the purchase of GHG credits when available.
Emission Trading	Emission trading would allow emission allowances or credits for emission reductions to be traded among market participants.
Carbon Taxes	A tax would be levied on carbon emissions.
Renewable Portfolio Standard [RPS(s)]	All energy suppliers licensed in a state being required to sell energy from renewable sources as a percentage of their total energy sales, with provisions for periodic review to evaluate effectiveness.

Direct Removal and Sequestration of CO_2 Emissions from Utility Boilers

As a basic concept, the removal of CO_2 from a voluminous gas stream is monumental and an unlikely technological accomplishment within low costs. On the principle that "one atom of carbon burned equals one atom of CO_2," the most efficient means to reduce CO_2 emissions may be to reduce combustion through increased energy conversion efficiency and/or conservation practices. Many have targeted reducing CO2 from large stationary combustion systems as a

[1] *Reducing Greenhouse Gases & Air Pollution: A Menu of Harmonized Options,* State and Territorial Air Pollution Program Administrators / Association of Local Air Pollution Control Officials (STAPPA / ALAPCO), Washington, DC, October 1999.

means to reduce greenhouse emissions from fossil fuel combustion systems. Proposals developed for reducing emissions, include fuel switching, efficiency improvements, CO_2 capture from conventional flue gas streams and oxy-fuel[1] fired systems with CO_2 capture.

Research continues at the US DOE and other organizations to further examine the potential for various add-on technologies as well as means to sequester CO_2 emissions in other forms. No conventional methods are yet available to efficiently and economically remove (wash out) significant percentages of CO_2 from the exhaust stream of a coal fired utility boiler. However, methods have been proposed, and are being tested, to accomplish this. Projected cost/power "penalties" for such advanced technologies are expected (by DOE) to range from 9% to 15% of plant generating capacity. Capital costs can also be significant for such reaction and recovery trains to remove the low concentrations of CO_2 in the flue gas.[2]

OXY-FUEL

One proposed way to help overcome some of the problems of collection, according to DOE, is to switch to oxy-fuel combustion. Use of oxygen in place of air creates a much lower volume of flue gas, which enhances thermal efficiency, thereby lowering CO_2 emissions, and resulting in lower quantities to treat. Since much of the flue gas consists of CO_2 and water, separation and purification are thus greatly simplified. These advantages have led several groups to explore oxy-fuel based boilers to enhance the boiler efficiencies and CO_2 recovery. A unit at Progress Energy has shown efficiency improvements from such a process (without recovery).

MOLECULAR SIEVE AND OTHER NOVEL COLLECTION & SEPARATION IDEAS

Another DOE research project is investigating a carbon fiber composite molecular sieve to remove CO_2. Other such projects sponsored by DOE include investigation of methods by which fly ash can be stabilized into conglomerates to be used as road construction or fill material and by which microbial processes could be applied to produce various carbonates by iron-reducing bacteria. Carbonates are produced *in situ* at the surface by photosynthetic algae and at depth by anaerobic carbonate producing bacteria. Microbial activities would convert CO_2 into a stable mineral; waste ash would be converted to a useful product. Leaching of heavy metals from fly ash ponds would be reduced/avoided, and other applications of this technology in agriculture or food processing are possible[3] as well as other novel ideas that are being pursued.

SEPARATION AND DUCTING TO DEEP UNDERGROUND COAL SEAMS

A major research area at DOE involves the collection, separation and "ducting" of CO_2 from the utility exhaust into deep unmineable coal seams to scavenge and/or "generate" methane, which is then forced to the surface for useful consumption. The objective of this project is to provide a wide range of benefits to the industry. The tasks include providing two significant

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[1] Advanced Oxyfuel Boilers and Process Heaters for Cost Effective CO2 Capture and Sequestration, US Department of Energy, http://dominoweb2.fossil.energy.gov/domino/apps/fred/fred.nsf, July 2003.

[2] Curt M. White, et. al., Separation and Capture of CO2 from Large Stationary Sources and Sequestration in Geological Formations – Coalbeds and Deep Saline Aquifers, National Energy Technology Laboratory, Pittsburgh, Pennsylvania; **Journal of the Air & Waste Management Association**; **Volume 53**, June 2003 (Critical Review Presented at the A&WMA Annual Conference, San Diego, Ca, June 2003.

[3] Biomineralization for Carbon Sequestration, U.S. Department of Energy, http://dominoweb2.fossil.energy.gov/domino/apps/fred/fred.nsf/ , July 2003.

field-demonstration sites that involve collecting or sequestering N_2/CO_2 mixtures, which is similar to power-plant flue gas. This project would also examine the feasibility of CO_2 sequestration in the broad set of conditions (coal types and emission compositions) that are likely to be encountered in the U.S. It would develop screening models to enable industry to quickly evaluate the technical and economic feasibility of CO_2 sequestration in coal beds for project specific conditions.[1]

As one may surmise, these and several other research areas are continuing to show progress. The difficulties of CO_2 removal are high, as will be the likely costs for accomplishing reductions. This is not to say that it is not worthy and necessary to research and develop, if possible, but the results will not likely be accessible for actual practical and economically feasible application within the time span of this effort. These areas must be followed closely and continually assessed.

Customer-Side Emission Reduction Options

The various use sectors (demand side) of electrical output use large quantities of electricity. Thus, many places have been identified for potential efficiency improvements. Much waste can be eliminated and consequently emissions from utility plants reduced, accordingly. A reduction at the customer sector will also translate to approximately 10% recovery of efficiency due to line loses that are not experienced from delivering that quantity of electricity.

Residential And Commercial Buildings Energy Consumption

Residential and commercial buildings consume, both directly and indirectly, over one-third of the fossil-fuel based energy in the US. Combined, these sectors represent the second largest source of GHG emissions in the US. Approximately two-thirds of the emissions from these sectors cause emissions at the electric generating facility. Electricity consumption is a result of lighting, heating, cooling and operating appliances. The remaining emissions occur on-site and result from direct consumption of natural gas and petroleum products used for space heating, water heating, and cooling needs etc.

Residential Energy Use

The residential sector is also a large consumer of fuels on-site and from electric energy generated elsewhere. Direct air emissions come from consumption of natural gas and other petroleum products utilized for space heating, water heating and cooking. In 1997, the residential sector directly consumed approximately 7.21 quadrillion British thermal units (quads) of fuel on-site.[2] See Figure 4.1 and 4.2.

Commercial Buildings Energy Use

The commercial sector accounts for 5% of the buildings in the US, but uses 40% of the building energy. In commercial buildings, the five largest end-uses are (1) miscellaneous

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[1] Geologic Sequestration of CO2 in Deep, Unmineable Coalbeds, US Department of Energy, http://dominoweb2.fossil.energy.gov/domino/apps/fred/fred.nsf/da9d8b7ff8a396df852569ff0049da5a, July 2003.

[2] Biomineralization for Carbon Sequestration, U.S. Department of Energy, http://dominoweb2.fossil.energy.gov/domino/apps/fred/fred.nsf/, July 2003.

equipment, (2) space heating, (3) lighting, (4) water heating, and (5) space cooling. In 1996, the commercial sector consumed 3.33 quads of electricity.

Figure 4.1: 1997 US Residential Electricity End Uses

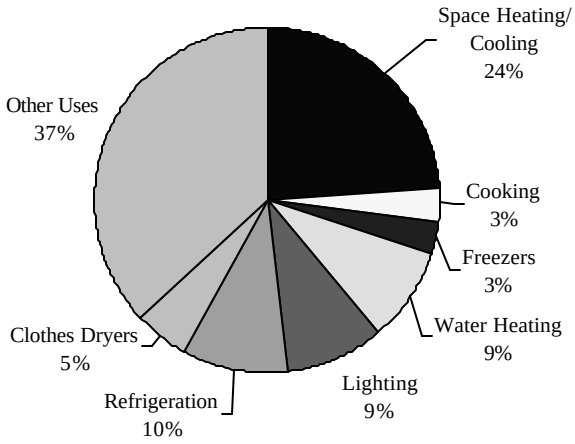


Figure 4.2: 1997 US Residential On-Site Energy Use by Fuel Type

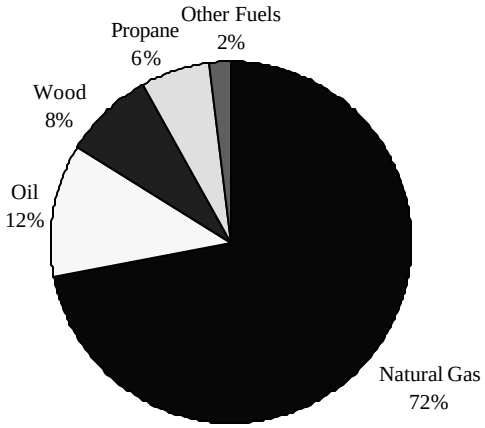
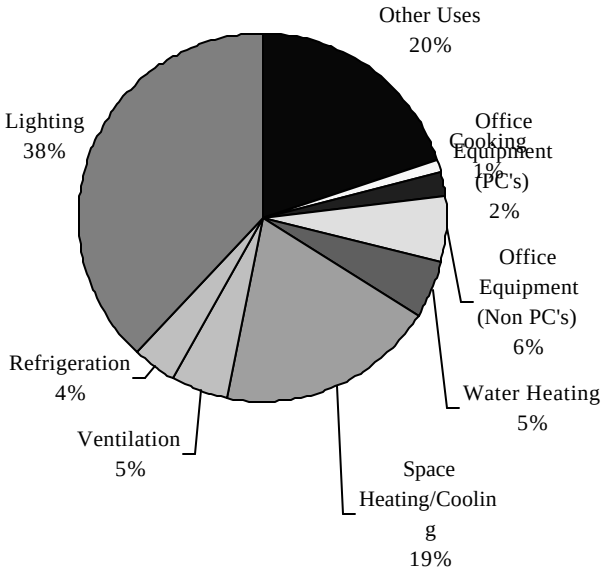


Figure 4.3: 1997 U.S. Commercial Electricity Use



Substantial quantities of emissions come from residential and commercial consumption of natural gas and other petroleum products utilized primarily for space and water heating and to power motors. In 1997, the commercial sector consumed approximately 3.7 quads of fuel on-site, with natural gas representing 91% of the fuel consumed, oil 1% and other fuels 8%. Table 4.3 below illustrates the CO_2 emissions per fuel type for both of the residential and commercial buildings sector.

Table 4.3: 1996 CO_2 Emissions (MMCTE) from On-Site Fossil Fuel Combustion

End-Use Sector	Coal	Natural Gas	Petroleum	Totals
Residential	1.4	77.4	27.2	106.0
Commercial	2.1	47.4	15.3	64.8
Total	**3.5**	**124.8**	**42.5**	**170.8**

POTENTIAL RESIDENTIAL/COMMERCIAL REDUCTION STRATEGIES

Several methods such as efficiency measures, equipment upgrades, and policy options that can be used to improve energy consumption in buildings.

- Thermal Efficiency Increases from Insulation
  - Thicker wall/ceiling
  - Retrofits with foam
- Air Sealing Measures[1]
  - Light Efficiency Measures
    - More efficient bulbs

[1] North Carolina's $ensible Greenhouse Gas Reduction $trategies, Appalachian State University, Department of Geography and Planning, Boone, NC, January 2000.

    - Better controls to minimize time on
- HVAC Efficiency Measures
    - More efficient heat exchange
    - Better controls to maximize comfort with less energy use
- Hot Water Efficiency Measures
    - More efficient heat recovery
    - Less heat loss to air
- Energy Audits
- Building Code Improvements
    - Increased wall and roof insulation requirements,
    - Increased window insulating values and require shading devices,
    - More stringent requirements for efficient heating and cooling systems,
    - Increased efficiency requirements for lighting systems, and
    - Requirements for better control over all energy-using devices that reduce consumption when the building is not occupied

Summary

The series of tables that follow summarize some of the technology-based and policy-based strategies that can be applied to the residential and commercial buildings sectors to achieve emissions reductions.

Table 4.3: Reduction Opportunities for Residential Emission Sector

Technology-Based Strategy	**Description**
Residential Sector	
Space Heating	High efficiency furnaces, high efficiency heat pumps and water- and ground-source heat pumps.
Small Appliances	Using energy-efficient designed products such as Energy Star
Water Heating	Use less, set thermostat lower, insulate the heater, and use a more efficient water heater – consider point of use heaters if possible
Lighting	Use compact high-efficiency and fluorescent lamps.

Table 4.4: Reduction Opportunities for Commercial Emission Sector

Commercial Sector	**Description**
Space Heating	Replace old heating systems with systems that include energy-efficient furnaces, boilers and geothermal heat pumps. Common retrofits are controls, improved chillers and maintenance.
Lighting	Use high intensity/low energy lights and improved controls.
Other Miscellaneous Equipment	Technologies that have significant potential to reduce energy use and emissions are motor drive systems commonly used in systems and processes such as conveyors, fans and pumping systems.

Table 4.5: Policy and Market Based Opportunities for Use/Emission Reductions

Policy-Based Strategy	Description
Voluntary Programs	1) Identify and promote profitable energy-efficient technologies, 2) Assist industry participants in marketing energy-efficiency products and services and 3) Educate the public about the benefits of products and services to stimulate consumer demand.
Building Energy Codes and Standards	More stringent energy requirements in building codes.
Utility Rebates/Incentives	Demand-side management programs to save energy Change building practices to include energy-saving design features through rebates and financial incentives.
Collaborative Efforts of Stakeholders and Consumers	Participate in ENERGY STAR Homes for residents and ENERGY STAR Buildings for commercial and industrial buildings & others.
Tax Credits	Tax policies that favor energy efficiency.
Emission Trading	Emission trading programs allow private entities, under certain circumstances, to buy and sell excess pollution reductions that they achieve.
Public Awareness and Education	Information programs that include advertising, educational campaigns, informational reports, voluntary actions, support for R&D, demonstration projects and technical assistance.

The *North Carolina's $ensible Greenhouse Gas Reduction $trategies*,[1] made several recommendations to achieve reductions and improve energy efficiency of existing and new commercial buildings and improve equipment and lighting. The measures defined would provide significant energy and cost savings. Table 4.6 summarizes these savings.

Table 4.6: Emission Reductions from Mitigation Strategies for the Commercial Sector

Strategy	CO_2 (million tons)	Percent of Total
Existing Buildings: Thermal Efficiency Improvements	1.38	1.3
Existing Buildings: Lighting Efficiency Measures	0.40	0.4
Existing Buildings: HVAC Efficiency Measures	0.23	0.2
Existing Buildings: Domestic Hot Water Efficiency Measures	0.07	0.1
Existing Buildings: Appliance and Office Equipment Measures	0.05	0
Fuel Switching: Solar Water and Space Heating	0.05	0
Fuel Switching: Electric to Natural Gas for Space Heating	0.33	0.3
Fuel Switching: Electric to Natural Gas for Water Heating	0.08	0.1
New Buildings: Improvements in Thermal, Hot Water and HVAC Efficiencies, Alternative Energy Options	2.82	2.7
Sector Total	**5.40**	**5.1**

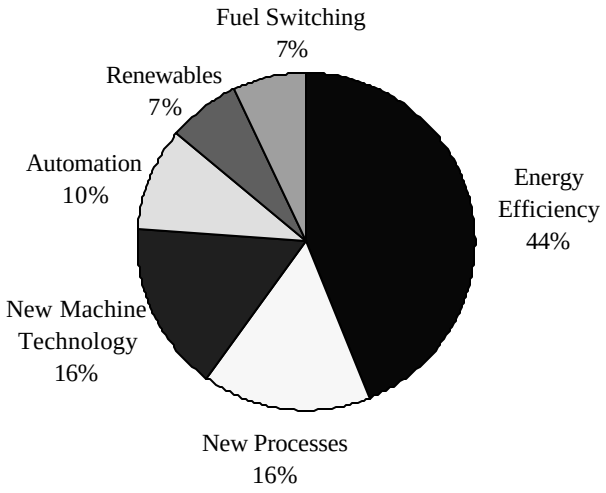
[1] North Carolina's $ensible Greenhouse Gas Reduction $trategies, Appalachian State University, Department of Geography and Planning, Boone, NC, January 2000.

INDUSTRIAL SECTOR

The industrial sector in North Carolina ranks first in terms of end use consumption of energy. Estimated final energy demand in the State's industrial sector was 447.3 trillion Btu or almost a third of all energy use in NC in 1997. Strategies to reduce GHG for energy intensive industries must focus more heavily on boilers and direct processes uses such as motors, compressors, and steam systems. Figure 4.4 displays the relative emissions saving from instituting the strategies outlined below.

North Carolina is known for its biotechnology industry, textiles, furniture, tobacco and paper products. This is only a small sample of the overall industrial sector in the state. Figure 4.5 lists the 20 primary Standard Industrial Codes and the number of employing businesses for each respective code type in North Carolina.

Figure 4.4 – Relative Emissions Reduction Contributions from Industrial Strategies



Energy Efficiency Measures

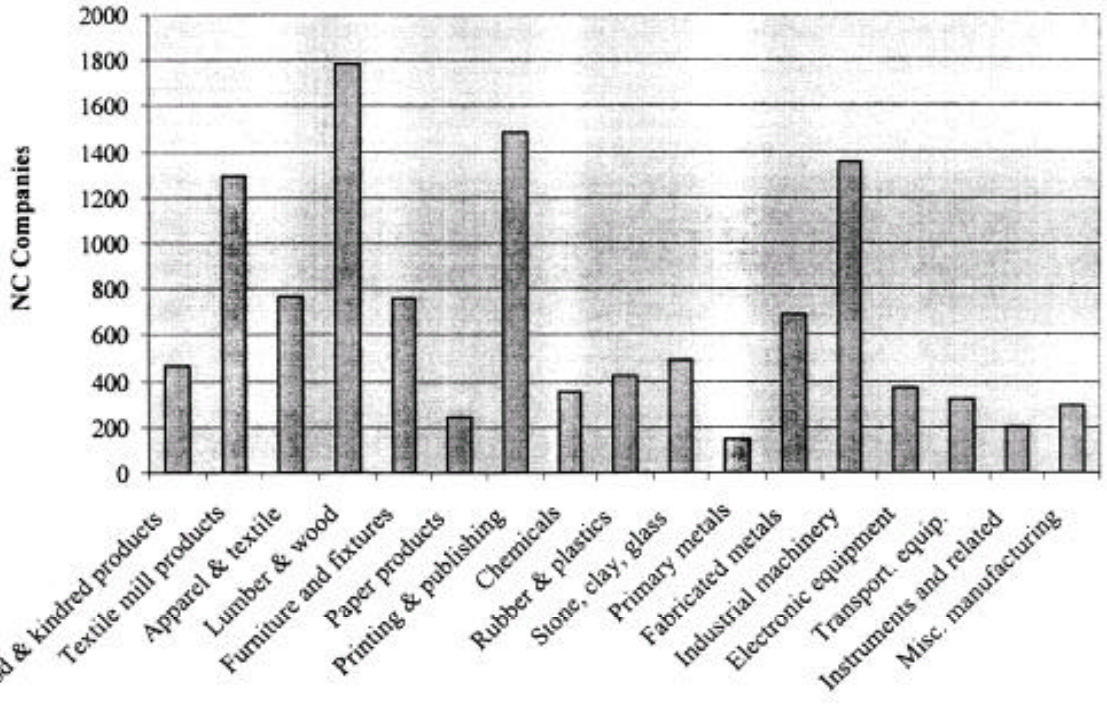
Several common measures were recommended from the ASU study [1] which is referenced herein as a major source document. These include:

- Boilers efficiency improvements evaluated included
  - Fuels used; including coal, wood, natural gas, fuel oil, and other petroleum products
  - Industries using most boilers are furniture, paper products, and chemicals
  - Average savings from efficient boiler measures can 3% of the total facility energy use.
  - Boiler load management

[1] North Carolina's $ensible Greenhouse Gas Reduction $trategies, Appalachian State University, Department of Geography and Planning, Boone, NC, January 2000.

        - Size for load
        - Tune-ups, maintenance and adjustment of air/fuel ratios
        - Waste heat recovery
    - Insulation and heat containment
    - Process waste heat recovery
    - Etc.
- Use of Compressed Air Systems
- Cogeneration
- Use of Energy Efficient Motors
- Heating and Air Conditioning Improvements
- Lighting Efficiency and Control Improvements
- Use of New Machine Technologies (more efficient)
- Automation

Figure 4.5 – Number of Companies in North Carolina by Industry Type



Policy Options

Four categories are available for CO_2 reductions in the industrial sector.[1] Table 4.7 highlights the programs under their respective category.

[1] North Carolina's $ensible Greenhouse Gas Reduction $trategies, Appalachian State University, Department of Geography and Planning, Boone, NC, January 2000.

Table 4.7– Summary of Policy Options Available for the Industrial Sector

Measure	Program Name
Direct Financial Incentives	Tax incentives for efficiency investments Subsidized loans for efficiency investments Carbon trading allowances
Regulatory Action	Mandated emissions limits Emissions portfolio standards
Recognition Programs	EPA **Energy Star** **Governor's Award** for Industrial Energy Innovation
Technical Assistance and Education	**Climate Wise** for Industry Industrial Assessment Center

Industrial Summary Remarks

The State's dominant industries, tobacco, woodworking, and textiles, are not energy-intensive. These industries generally require more precisely applied quantities of heat and do not produce large quantities of heat. However, a few high-energy intensive industries may provide an earlier pay back. Because of environmental concerns, natural gas and electricity usage will likely increase in this sector while the use of coal will diminish. Table 4.8[1] summarizes the relative emissions savings from instituting the above strategies.

Table 4.8 – Potential CO_2 Industrial Sector Emission Reductions Strategies

Strategy	CO_2 (million tons)	Percent of Total
Energy Efficiency Improvements	7.44	7.1
New Processes (Modernized Manufacturing Processes)	2.57	2.5
New Machine Technology	3.18	3.0
Automation	1.72	1.7
Fuel Switching: Coal to Natural Gas	0.64	0.6
Renewable	1.14	1.1
Total	**16.70**	**15.7**

North Carolina is projected to become more of a commercial and financial center and less of an industrial one. As a result, manufacturing employment is expected to decrease by 0.5% per year. Therefore, the future demand for energy in the industrial sector is predicted to be less than the demand in residential and commercial sectors.

Use of Energy Generation Options That Do Not Produce CO_2

Non-GHG producing energy is being used on site for direct thermal energy and electricity. Numerous promising options and programs exist and are under development to generate electricity or provide energy in a form for direct use. Every watt of such energy generated

[1] North Carolina's $ensible Greenhouse Gas Reduction $trategies, Appalachian State University, Department of Geography and Planning, Boone, NC, January 2000.

replaces a watt of energy that would have been otherwise generated by burning carbon fuels. However, this section only identifies some of the potential options. These will require further study, research, evaluation and discussion before any meaningful and useful recommendations can be made toward the objectives of the needs.

Technologies already identified and available for evaluation include:

- Solar walls - thermal collectors vertically oriented on a south-facing wall to provide space and process air heating
    - Power roofs – concentrating trough thermal systems for commercial roofs
    - Standard flat plate solar hot water collectors - used to produce high temperature water for preheating and processes
- Biomass combustion instead of coal- for example, co-fire wood residues with coal for heat production.
- Energy conservation measures already discussed and such factors as "white" reflective roofs to cut cooling loads (**Cool City Program**),
- Alternate electrical generation systems,
    - Wind turbines
    - Photovoltaic cells and systems
    - Fuel cells
    - Thermal Electric Systems
    - Hydro-power construction or renovation
    - Nuclear

Future versions of this report will address these further as far as they may relate to the scope and objectives of this effort.

Sequestration of CO_2 from the Atmosphere

Forests and other vegetation remove CO_2 from the atmosphere through their regular living and growing processes. Removal of wood and processing into houses and other structures tend to sequester the carbon from the air and make permanent or semi-permanent forms of carbon containing materials that will hold on to the carbon for long periods of time (e.g. until building demolition, burning, etc.). Maintenance of standing timber/forests also retains carbon in a solid form not released into the atmosphere. However, removal and burning of vast forests, such as in the South American rain forests releases large quantities of CO_2. Wild fires and controlled burning for forest management also release considerable CO_2. Burning also removes these sequestering organisms from the sequestering side of the equation and has a detrimental effect on the Earth's capacity to remove CO_2 from the atmosphere. Although research[1] has shown a natural ability of existing vegetation to adapt and take on more CO_2 at a higher rate in higher concentrations, but this is not adequate to make up for the extra carbon burned.

Many potential policies and projects have been initiated and proposed that would result in the planting large quantities of vegetation to take further advantage of the natural sequestration

[1] The Duke Forest FACE facility; FACE Project, Duke University, http://c-h2oecology.env.duke.edu/Duke-FACE/description.cfm, July, 2003.

capabilities of vegetation. Research has also shown that biological modifications may be possible to generate more "CO_2-hungry" forms of vegetation. However, since vast quantities of forest have been cut and large emissions of CO_2 have been emitted from these and fossil fuels, huge quantities of vegetation would need to be grown to capture all the "extra" carbon. This vegetation then will need to remain unburned, to make significant differences in the levels of CO_2 in the atmosphere.

Biotechnology may hold some promise for moderating global warming caused by the greenhouse effect. The type of genetic enhancement possible through biotechnology is not going to change dramatically rates of terrestrial carbon sequestration or bypass the laws of thermodynamics, however. Researchers are focusing on several possible ways biotechnology might help on both fronts. Some crops already being designed to withstand wind could help sequester more carbon into soils, says agronomy professor Charles Rice of Kansas State University[1]. For example, corn that is engineered to grow thicker, woodier stalks uses more carbon. The carbon is needed to make all the woody lignin and cellulose that makes them thicker and stiffer. Lignin and cellulose are slow to decompose in the soil, says Rice, "The more biomass you produce, the more carbon that's put into the soil." The DOE's **Center for Research on Enhancing Carbon Sequestration in Terrestrial Ecosystems (CSiTE)** is studying many grasses, trees and all manner organic and inorganic ways to sequester carbon and enhance carbon capture and long-term sequestration.

Biomass-derived ethanol has been touted as a potential liquid fuel replacement for gasoline. However, finding a substitute for oil, a high-energy-density liquid fuel that has powered the U.S. economy for more than a century, will not be quick or easy. Indeed, it's likely that nothing will replace the convenience and versatility of petroleum until it is forced by unavailability. Ethanol production from corn produces a net energy loss, so research scientists are studying the feasibility of using cellulose feedstock (agricultural and forestry wastes, grasses and certain components of municipal waste) to produce biofuel more efficiently. Producing cellulosic ethanol from trees and grass may be more efficient than using corn, but ultimately, the energy required to mine ore, produce steel, and manufacture tractors and farming equipment; and the amount of fuel, whether ethanol or biodiesel, needed to harvest, transport, and process the biomass is often greater than that contained in the ethanol produced. This has not deterred the push for increasing the production of ethanol.

[1] Charles Rice, Carbon Sequestration: Top 10 Frequently Asked Questions, http://www.mediarelations.ksu.edu/WEB/News/NewsReleases/questions.pdf, Kansas State University, Manhattan, Kansas, July 2003.

Chapter 5 Existing NC Programs Pertinent to CO_2 Reductions

Several programs in North Carolina already exist that follow the principles required for reduction of carbon energy use and thus the production of CO_2. The list below is only a sampling of them.

NC Climate Wise

Climate Wise[1] is a government-industry partnership designed to help businesses turn energy efficiency and environmental performance into a corporate asset. It is based on a concept that what is good for business is good for the environment. According to Climate Wise Partners and officials, actions to improve energy efficiency and reduce greenhouse gas emissions save money and boost productivity. The base program is jointly sponsored by the US DOE and the EPA. The program is designed to help business and other organizations to be innovative and provides access to technical and financial assistance. The program in North Carolina was funded by the state until the budget problems forced its discontinuation. It has now been "privatized" in the form of a non-profit company called **Global Warming Initiatives** that is run from the NC State Centennial Campus. Thirty-nine companies have participated in the program in previous years and high interest continues.

Climate Leaders

Climate Leaders[2] is an EPA originated voluntary industry- government partnership that encourages companies to develop long-term comprehensive climate change strategies and set GHG emissions reduction goals. The program has just recently been initiated and no statistics have been seen on its success.

The **Climate Leaders** agreement spells out that the company will:

- Develop a company-wide inventory of GHG emissions annually as outlined by **Climate Leaders'** emission protocol's Core Module (direct emissions and emissions from electricity use).
- Report its GHG inventory data annually.
- Enter into discussions with EPA to develop an aggressive corporate-wide GHG reduction goal to be achieved over 5 to 10 years.

Climate Challenge

Climate Challenge began in 1994 as a DOE program. Through a mechanism of **Participation Accords**, Duke Power Company (Duke Power) and DOE agreed to participate in the **Climate Challenge Program** in pursuit of the President's goals for reducing greenhouse gas emissions. The **Climate Challenge** program is a joint, voluntary effort of DOE and the electric utility industry to reduce, avoid or sequester greenhouse gas emissions. The framework of

[1] GWI Services; http://24.172.16.181/docs/gwi%20services.pdf July 2003.

[2] Climate Leaders Partnership Agreement, http://www.epa.gov/climateleaders/pdf/agreement.pdf, EPA, Washington, DC, July 31, 2003.

Climate Challenge was established in the project's Memorandum of Understanding.[1] The program was developed with the intent of running through 2000. It was to accomplish the following elements under the agreement.

- Financial contributions to assist in promotion and support of the program
- Improve the capacity factor for their nuclear generation
- Realize improvements in hydro capacity, thereby displacing fossil generation
- Increase the utilization of combustion ash
- Reduce system losses on transmission and distribution system
- Conduct a program to increase the efficiency of fossil stations
- Purchase electric vehicles (EVs) and evaluate them
- Maintain efforts to be first in the nation in coal-fired heat rate
- Implement special rates for recharging EVs as an incentive for others to purchase
- Set and meet challenging goals for the corporate recycling of paper, cardboard, aluminum, glass, and other products, and
- Perform energy efficiency audits to implement measures that make economic sense.

Energy Star Partners

Energy efficient homes can be certified to meet the standards of the EPA's **Energy Star**® program[2,3]. The homes meeting these standards help reduce annual energy costs by up to 30 percent; thanks to their high-efficiency heating and cooling equipment and high-quality materials and construction. These standards also result in greater comfort year-round. In some cases, the power supplier provides incentives such as Progress Energy, which takes 5 percent off the customer's total monthly electric bill. The savings over the life of the home are substantial and the benefits include the potential for higher resale value and significant savings on financing. The **Energy Star** standards are assured by a third-party verification process to assures customers and the public that the homes meets these standards and, thus, qualifies it for a discount and other advantages.

The program also extends beyond the residential setting into commercial and other areas. As an example, Food Lion[4] as well as others have been recognized as Energy Star Partners

GreenPower

Green Power is synonymous with renewable energy resources. It denotes that the electricity is "greener" than electricity generated from traditional sources. Such sources can include nuclear, large scale-hydro, photoelectric and others, and results in lower or no air pollution emissions.

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[1] Climate Challenge Participation Accord, http://www.eere.energy.gov/climatechallenge/cc_accordxDUKE.htm, Duke Energy, Charlotte, NC, July 2003.

[2] Energy Star; http://208.254.22.6/index.cfm?c=bldrs_lenders_raters.pt_bldr; USEPA, Washington, DC, July 2003.

[3] Energy Efficient Home Program; http://www.progress-energy.com/custservice/carres/energyhome/index.asp; Progress Energy, Raleigh, NC, July 2003.

[4] Food Lion earns award for exemplary energy efficiency efforts, http://www.foodlion.com/cor_news.asp?parm=216, Salisbury, NC, March 2003.

NC'S NEW **GREENPOWER** PROGRAM

NC GreenPower is a new program designed to improve the environment by encouraging the development of renewable resources in North Carolina. **NC GreenPower**[1] will provide electric consumers with an opportunity to voluntarily purchase green power at a small premium. The program is a cooperative effort between renewable energy generators, electric utilities, and electric consumers to implement and support green power generation in North Carolina. Under this voluntary program (announced July 28, 2003, but starting full operation in October), customers are provided the option to pay an additional $4 on their electric bills for each block (100 kilowatt-hours) of energy produced from wind, solar or methane sources. Utilities then must get that block of energy from a "green" energy generator. The concept is that for every block of clean energy purchased, one fewer block of power will be produced by fossil fuels.

The program offers two basic options to electric customers: a mass-market product available to everyone and a large volume product available to customers who purchase a minimum of 10,000 kWh or more from the program per month. All qualifying **NC GreenPower** resources will be used to supply the demand for the large volume product.

This program will enable the development of multiple types of renewable energy in NC. Initially, the mix of renewable resources used is expected to emphasize biomass (agricultural and wood waste, energy crops), landfill gas (methane), and small hydro. These sources are available, plentiful and facilities to utilize them can be constructed quickly. Solar and wind are a bit more expensive and will be developed later along with photovoltaic and wind generation sources. The program would benefit from state income tax credits for renewable energy technology deployment and Federal tax incentives.

Renewable portfolio standards (**RPS**) are required programs somewhat similar to the voluntary **Green Power** programs. They require each utility selling power in an area to use renewable energy generation to generate a certain percent of its electricity. The **RPS** are billed as a flexible and easily verified means to guarantee that renewables grow in the market. The **RPS** are expected to help lower cost and increase the competitiveness of renewable technologies by increasing sales, commercialization, and use of available technologies. Shortcomings of the **RPS** include that it will probably not promote new and emerging technologies, not readily expand beyond existing renewable installations, likely not foster research and development needs or protect low-income consumers.

PUBLIC BENEFITS FUND

A converse option to the RPS employed in some areas, is a **Public Benefits Fund**. This is a charge applied to the sale of non-renewable generated electricity and is similar to the system benefit charge used in some states. The purpose of the fund is to collect and distribute money for investment in actions that are in the public interest, but which would not happen in a regulated or unregulated market. The fund is collected from each ratepayer as a small fraction for each kWh sold. It can support smaller scale renewable energy projects, energy efficiency projects not done by the market place, training, consumer education, low interest loans, and other refinancing

[1] NC GreenPower Is Here; http://www.ncgreenpower.org/ , July 2003.

mechanisms as well as funds for low-income assistance. As a policy tool, the public benefits fund is applicable with or without the restructuring of the utility industry.

In the absence of restructuring legislation, the NC Utilities Commission can establish such a fund. A public benefits fund is also necessary when an **RPS** program is implemented because the **RPS** typically favors economical and established renewable technologies. While supporting the goal of the **RPS**, the public benefits fund will also commercialize newer technologies, provide affordable loans for in-state, smaller scale, renewable and efficiency projects, and create new local jobs and businesses. See the discussions of the proposed **State Energy Plan** that appears below.

Advanced Energy Corporation

Advanced Energy Corporation was previously known as Alternative Energy Corporation, or AEC. They were founded by the NC Utilities Commission in 1980 to explore alternative ways of producing electricity and get more work out of the electricity (especially motors) already available.

Located in Raleigh, North Carolina, **Advanced Energy** is a national resource that focuses on industrial process technologies, motors and drives testing, and applied building science, with state-of-the-art laboratories in which to do testing and applied research. They are a non-profit corporation that creates economic and environmental benefits through innovative approaches to energy. They offer consulting, testing, and training, and strive to develop innovative solutions to energy problems. Their primary mission is to increase efficiency and productivity in industries, businesses, and homes (especially through use of improved efficiency motors) as they transform energy into goods, services, and environmental conditioning. They work with utilities to develop programs and services to benefit their customers. They work with industry to test new equipment, help develop new products, and improve manufacturing processes. For the building industry, they help builders, developers, and mechanical contractors improve homes and small commercial buildings.

Over the last few years as competition has entered the industry, many utilities have cut or eliminated research and development, renewable energy and Demand Side Management programs and funding. This applies to NC investor-owned utilities' where demand side management, and research and development programs have been reduced in recent years from 1993 levels when these funds amounted over $125 million. In NC, a per kWh charge is now used to fund (by legislative statute) the NC Utilities Commission and the Public Staff, and to fund **Advanced Energy Corporation** by voluntary participation of the investor-owned utilities and rural electric cooperatives. For example, **Advanced Energy Corp**.[1] currently collects $0.00003567/kWh (approximately $3.5 million annually).

Waste Reduction Partners

Waste Reduction Partners[2], previously known as the **Waste Reduction and Technology Transfer (WRATT)** program, was established in 1992, through the collaborative

[1] About Advanced Energy; http://www.advancedenergy.org/general/about_us/index.html, July 2003.
[2] Waste Reduction Partners; http://landofsky.fp.skyrunner.net/wrp/About_WRP.htm, July 2003.

efforts of the Tennessee Valley Authority, Land-of-Sky Regional Council, and the North Carolina Division of Pollution Prevention and Environmental Assistance. The program, headquartered in the Asheville area, was formed to assist WNC businesses, industries, institutions, and governmental entities reduce waste and utilize natural resources more efficiently free of charge.

The **Waste Reduction Partners** team conducts on-site assessments and provides technical assistance to businesses and public facilities throughout Western North Carolina. WRP helps organizations improve environmental and energy management through efficiency techniques that save money. The team emphasizes innovative cost-saving strategies and resources that promote environmental excellence and pollution prevention. All work performed is confidential and provided at no cost to the recipient.

High Performance Building Guidelines

DOE has initiated a number of programs[1], which have been picked up by various organizations across the country, that encourage higher efficiency in buildings through improved standards. A high performance commercial building design strategy requires a clear definition of goals and performance benchmarks from the owner and an inter-disciplinary design and construction approach. Design criteria should be based on environmental and energy cost/benefit analyses and attention to "whole-building" and system performance. North Carolina has adopted a set of such standards.

North Carolina's High Performance Guidelines [2]provide a model for the design and construction of energy efficient, cost-effective, durable, and environmentally sound buildings. These programs are supplemented by:

- Energy code assessment and training,
- Energy improvement loan programs,
- And energy efficiency in state construction,
- Center for Energy Research and Technology (CERT), an energy education institute at North Carolina A&T State University,
- University Research focused on energy use and energy efficiency in manufactured housing, solar electricity in public housing, and the development of fuel cells,
- Clean Technology Demonstrations that develop partnerships with North Carolina colleges and universities to demonstrate clean energy technologies, such as fuel cells, biomass, wind, solar, and geothermal,
- Energy Efficiency in State Construction, with projects to demonstrate energy improvements in lighting, boiler controls, HVAC controls, chilled water systems,
- And other energy efficiency measures in state and university buildings,
- Energy for Buildings provides industrial companies with assistance in their efforts to reduce emissions of carbon dioxide and other greenhouse gases that contribute to both global warming and air pollution,
- Provide training and presentations about the High Performance Guidelines that have recently been developed by Triangle J Council of Governments,

[1] High Performance Buildings; http://landofsky.fp.skyrunner.net/wrp/default.htm. July 2003.
[2] High Performance Guidelines; http://www.doa.state.nc.us/energy/Energy2/build.htm, July 2003.

- Targets policy makers, designers and other professionals who design, build and manage public schools, state and local government buildings, and facilities at universities and community colleges,
- Housing Energy Efficiency program to create a market demand for homes that exceed the North Carolina Energy Code,
- Home energy rating & documentation for a program recognized by the national mortgage industry,
- Provides matching funds for costs associated with increasing the energy efficiency of local government buildings,
- North Carolina Energy Code Assessment and Training to evaluates the effectiveness of residential and commercial building energy codes and enforcement in the state,
- Public School Energy Improvement that provides matching funds for costs associated with increasing the energy efficiency of K-12 public schools (now in Lee County only), and
- Steam Trap Surveys that assist businesses by identifying and reporting the condition of steam traps, specifying those needing repair or replacement.

Overall, this appears to be an extensive and very helpful program contributing to reduced electric requirements, which in turn reduces emissions of CO_2 to the atmosphere.

Leadership in Energy and Environmental Design (LEED)

The **U. S. Green Building Council** (USGBC) is a coalition of members from the building industry who are promoting buildings that are environmentally responsible, profitable and healthy places to live and work. The **LEED** Green Building Rating System is a national consensus-based rating system designed to result in green building practices. It entails the design, construction and certification of these buildings. They provide workshops, accreditation, resources and third-party certification. They also hold a **Greenbuild** conference annually to exchange information within the industry and a Federal Summit to interact with the regulators within the federal arena. They have several committees and sub committees which work on the various aspects of their aims. The efforts of this organization are recognized as being influential toward reduction of GHG's directly and through increased energy efficiencies and subsequent fuel and emission reductions.

NC Energy Plan

NC's General Assembly established the **Energy Policy Council** (EPC) in 1975 to address energy issues and concerns in North Carolina. The **1992 NC Energy Plan** provided the Council's last examination of energy use, energy production, and environmental concerns in the state. Since state and national energy issues have changed during that time, an updated plan was developed. Through development of a proposed new **State Energy Plan**,[1] NC has taken positive action toward reduction of energy waste, which translates directly into reductions in CO_2 emissions. The plan is based on a premise that the state's energy industries continue to provide high quality, reliable electricity and fuels to buildings and industry.

[1] The (Proposed) North Carolina Energy Plan, Chapter 1; http://www.ncenergy.appstate.edu/index.php, June, 2003

The **Energy Policy Working Group** recorded and organized the input received and, after months of extensive deliberation, provided a draft set of recommended policies and programs to the **Energy Policy Council** in January, 2003. The Council discussed the recommended policies and programs and approved 93 measures, as set forth herein, that meet the plan's objectives. The policies and programs approved by the **Energy Policy Council** primarily addressed the following sectors and issues in the state:

1. Energy, Economics, and the Environment, Fossil and Nuclear Fuels,
2. Electric Utilities and Energy Use,
3. Alternative Fuels from Biomass,
4. Alternative Energy Sources and
    - Energy Use in
        - the Public Sector
        - the Residential Sector
        - the Commercial Sector
        - the Industrial Sector
        - the Transportation Sector,
5. Energy Education and Research and
6. Funding for Energy Policies and Programs

IMMEDIATE ACTION ITEMS

The EPC reviewed the entire list of 93 policies and programs to determine which measures would require action by the Governor, NC General Assembly, NC Utilities Commission, or other regulating or administrative agency. From the entire list, the EPC recommended 15 key legislative, regulatory, and administrative policies for action in 2003 and 2004[1] (these are slightly edited and shortened below from the original text):

Energy, Economic, and Environmental Issues

Exec-1 The NC Department of Commerce (DOC) and the SEO should encourage and support economic development of energy-related enterprises whose products are intended to increase energy efficiency or use renewable resources, such as providers of specialized insulation and window products, heating and air conditioning equipment and controls, distributed generation equipment, solar and wind energy equipment, and fuel cells.

Exec-2 The SEO should communicate the energy research being performed in the state to the NC DOC for its development strategy.

Exec-3 The NC DENR should create a greenhouse gas registry to track emissions of carbon dioxide and other greenhouse gases,

Alternative Fuels from Biomass

Exec-4 NC should support the development of an alternative fuel industry through dedicated funding and grant matching of promising alternative fuel projects (including agricultural waste processing facilities, biodiesel and ethanol). NC should support the development of an alternative fuel industry through dedicated funding and grant. These efforts should include agricultural waste processing facilities, biodiesel and ethanol refineries, fueling stations for alternative-fueled vehicles, production incentives for farmers and refiners, incentives

[1] North Carolina Energy Plan, Executive Summary, http://www.ncenergy.appstate.edu/plan/ , July 2003.

for highly efficient or alternative-fueled vehicles, and education and awareness programs. Insure that all 100 counties in the state have alternative fueling infrastructure by 2007. The EPC supports a program to pay for alternative fuels development via a $1 to $2 fee applied to annual vehicle registration fees.

Exec-5 The NC General Assembly should pursue strategies that convert animal waste into environmentally sound energy sources.

Alternative Energy Sources

Exec-6 The General Assembly should consider adopting net metering for application to all electric utilities in the state.

Exec-7 The General Assembly should evaluate a renewable portfolio standard (**RPS**) that complements the NC **GreenPower** program and fosters the development of a renewable electricity market. This should require that all electric utilities increase the percentage electricity that comes from renewable sources.

Exec-8 The General Assembly should reexamine the Mountain Ridge Protection Act as it pertains to wind energy while still protecting NC's natural beauty.

Exec-9 The SEO should assess and propose incentives and regulatory or administrative measures for development of renewable electricity generation facilities, solar water heating, passive and active solar space heating, and lighting.

Exec-10 The General Assembly should require that all electric utilities in NC provide generation disclosure of fuel mix percentages and emissions statistics on sulfur dioxide, nitrogen oxides, carbon dioxide, and mercury annually by bill insert and via website.

Energy Use in the Public Sector

Exec-11 State agencies and universities, with coordination by the NC Department of Administration, should reduce energy consumption in state buildings by 20% by 2008, 4% per year or more for the next 5 years. The SEO should submit an annual report to the Energy Policy Council, the Governor's Office, the State University System and other major energy users in NC to summarize the source, cost and energy efficiency activities undertaken, the approximate investment in energy efficiency measures, and their overall economic costs and benefits.

Exec-12 Working in conjunction with the State Construction Office, the SEO should monitor, analyze, and report on the energy savings attributed to the new requirements on life-cycle cost analyses of the $3.1 billion higher education building program currently underway. The SEO should maintain records of the consequences of effects of life-cycle cost procedures.

Exec-13 NC should facilitate efforts of local governments to finance energy efficiency and renewable energy projects to achieve economies of scale and improve opportunities for financing, restructure the underwriting provisions of the SEO's low-interest energy loan program, and provide training in energy efficiency.

Energy Use in the Residential Sector

Exec-14 NC State Government should continue to support a strong low-income weatherization program to include review of the effectiveness of energy conservation programs conducted through the program and opportunities for improvements. The SEO should develop additional programs to address energy-efficient housing in the low-income sector.

Funding for Energy Programs

Exec-15 The General Assembly should review options, such as a Public Benefits Fund or other means, to enable funding of the basic services provided by the State Energy Office and the recommendations in the State Energy Plan.

Generalizations

In addition to the above, the proposed **NC Energy Plan** includes many other detailed recommendations and observations, many of which have been referenced previously in this document. Many other programs and resources exist that may likely have merit for discussion but are omitted here.[1]The CSA appears to be in consonance with these (proposed) policies. In addition, other new state and federal regulations on vehicle emissions will ultimately reduce emissions from cars and trucks and be in harmony with the stated purposes of the plan. Other new and ongoing programs will continue to promote energy efficiency and renewable resources that will reduce required uses of fuels. Though the charge of DAQ under the Section 13 of the CSA does not include the review, endorsement or otherwise mention the NC Energy Plan, they appear to be quite complimentary and headed toward similar and compatible objectives. The melding or alignment of these efforts will no doubt further evolve as these efforts march forward in the next few months and years.

[1] Advanced Energy Links; http://www.advancedenergy.org/root/general/links.html, July 2003.

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Chapter 6 Interim Conclusions and Expectations

This report has been generated with the intent of providing background and state of knowledge as relates to emissions of CO_2 in North Carolina and elsewhere, the options for reduction and/or removal of these emissions from the atmosphere and a summary of state, national and international processes that relate to the actions or proposed actions in NC. The 2004 and 2005 reports will provide more information and eventually NC-specific recommendations on what should be done to reduce emissions of CO_2 from NC coal-fired power plants and other stationary sources.

Proposed Stakeholder and Public Workshop

In connection with our preparation of the 2004 Report, the Division of Air Quality is planning to hold a workshop to provide information and to solicit discussion of issues, viewpoints and other information needed to make the final decisions required by this Section of the CSA. We expect to discuss a list of issues and topics for which there are currently gaps of information and understanding, or for which there is a benefit of stakeholder feedback. These issues will be targeted at specific persons or organizations who will agree to prepare written papers on the topic(s) outlined, with as much supporting information and reference material as possible. At the conclusion of the workshop, these papers will be used to prepare a proceedings report for the meeting. An introduction, with an overview and the summation of the DAQ's view on the material and positions presented will be prepared and included as a part of these proceedings. Our intent is to provide this information and summary to the EMC and ERC as the 2004 report. This process will provide a means of identifying further issues and gaps that must be filled prior to the final 2005 report.

Economic Costs and Benefits

Currently, the costs of various options for reducing emissions of CO_2 are essentially in a state of flux that likely will not begin to stabilize until significant decisions are made and issues resolved at the national and international level. The fluctuating prices of natural gas, aggravated by increased demands upon a supply that is claimed adequate for needs on one day but pointed out to be unavailable because of transport and location factors the next, further complicate the uncertainty and method of dealing with optimum planning for the future. In addition, the research level of most of the sequestration and removal activities for collection and safe, stable, long-term disposal exacerbates the problems to make defensible statements on the economics. As this effort progresses over the next two years, many of these decisions will likely be made and it will be possible to collect more meaningful data and provide them in a manner that will be of benefit to these studies for the CSA. The DAQ will undertake what it is able, but most of these types of efforts will be subject to national forces.

Appendix A - General Background for CO_2 and Other GHG

DAQ staff feels it is important to the task of understanding the associated phenomena and regulatory options or requirements that a basic set of information be provided as background. This is the context and purpose of this appendix.

CHEMICAL/PHYSICAL ATTRIBUTES OF CO_2

CO_2 is a colorless, odorless gas that exists normally in the atmosphere in concentrations currently in the range of 370 parts per million by volume. Since it occurs naturally in ambient air and does not directly impair human health at ambient levels, it is not considered an "air pollutant" under the current interpretations of the Clean Air Act. This interpretation is currently being challenged in the courts by a collection of northeastern states.[1] Although at high concentrations CO_2 will displace the body's ability to take in oxygen and cause suffocation, it is not normally considered a toxic gas at normal ambient concentrations. In fact, the human body generates and exudes low concentrations of CO_2 as a product of the normal oxidation process of the body to generate energy from food. Thus, the body takes in oxygen, combines it with the carbon in the food, and releases the CO_2 as a by-product, which in turn is taken up by plants to use to generate oxygen and maintain the cycle.

SOURCES OF CO_2

CO_2 results when any carbon-containing material (fuel) burns. CO_2 is the GHG emitted by human activities in the largest quantities because it is a primary product of fossil-fuel combustion, as in coal-fired utility boilers and automobiles, vegetation burning, normal vegetative decomposition, and other such activities. Whether fossil or renewable, most fuels are carbon. Fossil fuels include coal, oil, natural and gas, which be believed were formed from prehistoric plant and animal matter that has been exposed to great pressures under the Earth over billions of years. Renewable fuels such as grain (ethyl) and wood (methyl) alcohols, which result from carbon compounds being formed within historic times and are available in the form in which they "grew" or derived from there, such that they result from sequestering carbon atoms from the "recent" atmosphere. These fuels are considered renewable because they can be produced or harvested by human activities and can be replaced within a few years or lifetimes as opposed to processes beyond the consideration of man that take millions or billions of years to achieve. Although there are reasons to promote the combustion of renewable fuels over fossil fuels, the burning of one atom of carbon will generate one molecule of CO_2 no matter the source of that carbon atom. In reality, natural decomposition is a form of "slow combustion" and contributes to the emission load. More details on the sources in general, and particularly in North Carolina, are presented later in this report.

In 2000, total estimated U.S. GHG emissions rose to 7,011 teragrams of carbon dioxide equivalent (Tg CO_2 Eq).[2] The increase from 1999 to 2000 was 2.5%, which was greater than the

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[1] Commonwealth of Massachusetts, State of Connecticut, and State of Maine, Civil Action v. Christine Todd Whitman, Defendant, in her capacity as Administrator of the United States Environmental Protection Agency United States District Court, District of Connecticut, June 4, 2003.

[2] Inventory of US GHG Emissions and Sinks 1990-2000,US EPA, Washington, DC, April 2002.

average annual rate of increase between 1990 and 2000 that was 1.3%. The higher than average increase in emissions in 2000 was, in part, attributable to robust economic growth in 2000, which led to increased demand for electricity and transportation fuels, cooler winter conditions compared to the previous two years, and decreased output from hydroelectric dams. The largest source of CO_2 and the overall GHG emissions continues to be fossil-fuel combustion.

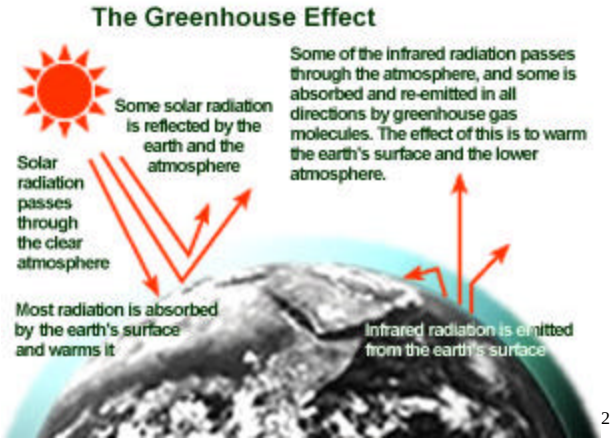
UNDERSTANDING THE GREENHOUSE PHENOMENON

For many years, there have been speculations and suppositions regarding the warming or cooling of Earth due to various physical forces and phenomenon. However, in the early 1960s, more and more scientists started to more seriously investigate and take actual measurements in a consistent manner so that they began to clearly recognize that concentrations of carbon dioxide in Earth's atmosphere were increasing every year. Because current concentrations of GHG keep Earth at its present temperature, scientists postulated that increasing concentrations of GHG would make the Earth warmer.[1] In computer-based simulation models, rising concentration of GHG nearly always result in an expected increase in the atmospheric temperature of Earth. (Note: Although this report is oriented toward CO_2 from coal-fired utility boilers, other GHG are discussed for completeness and context).

Average Earth Temperature

GHG, especially CO_2, result from burning coal, oil, and natural gas as well as wood and other organic matter from activities such as deforestation, burning of waste, prescribed burning, forest fires and land clearing. Natural decay of organic matter also results in such emissions. Over the last century, GHG have been emitted faster than natural processes, such as plant growth-carbon sequestration, can remove them. In a natural state, GHG would keep the Earth's surface about 60^{o} F warmer than it would be without them. These GHG's trap outgoing energy and retain heat in similar manner to glass panels in a greenhouse and slow heat loss by re-radiation back to space.

Figure A.1: Illustration of the Greenhouse Effect



[2]

[1] Advanced Oxyfuel Boilers and Process Heaters for Cost Effective CO2 Capture and Sequestration, US Department of Energy, http://dominoweb2.fossil.energy.gov/domino/apps/fred/fred.nsf, July 2003.

[2] Climate Change: State of Knowledge, Office of Science and Technology Policy, Office of the President, Washington, DC, October 1997.

Contributors to Greenhouse Gases

Since the beginning of the industrial revolution, scientists have reconstructed information showing that atmospheric concentrations of CO_2 have increased nearly 30%, while methane concentrations have more than doubled and nitrous oxide concentrations have risen by 15%.[1, 2] Fossil-fuels burned to operate cars and trucks, heat homes and businesses, generate electricity and power factories are responsible for about 98% of US carbon dioxide emissions, 24% of methane emissions, and 18% of nitrous oxide emissions. In addition to fossil fuel combustion, increased agriculture, deforestation, landfills, industrial production and mining, all are significant tributors to GHG emissions. In 1994, the U.S., with about 5% of the globe's population, emitted about 20% of the Earth's total GHG.

Changes in CO_2 emissions from fossil fuel combustion are influenced by long-term and short-term factors, such as population and economic growth, energy price fluctuations, technological changes, and seasonal temperatures. Consumption of fossil fuels fluctuates in response to changes in economic conditions, energy prices, weather, and availability of non-fossil alternatives. Long-term changes in energy use patterns are largely a function of changes that affect the scale of consumption (e.g., population, number of cars and size of houses), the efficiency with which energy is used in equipment (e.g., cars, power plants, steel mills and light bulbs) and consumer behavior (e.g., walking, bicycling, or telecommuting to work instead of driving). Energy related CO_2 emissions are also a function of the type of fuel or energy consumed and its carbon intensity. Producing heat or electricity using natural gas instead of coal, for example, can reduce the CO_2 emissions associated with a specific quantity of energy consumption because of the lower carbon content of natural gas per unit of useful energy produced. This is not to say that there are not other trade offs and considerations, such as the increased use of natural gas, which inevitably causes increases in its price, and it may not be adequately available.

Energy-related activities accounted for the majority of US CO_2 emissions between 1990 and 2000. CO_2 from fossil-fuel combustion was the dominant contributor. In 2000, approximately 85% of the energy consumed was produced through fossil fuel combustion. The remaining 15% came from other energy sources such as hydropower, biomass, nuclear, wind and solar energy. From 1990 to 2000, petroleum supplied the largest share of US energy demands, accounting for an average of 39% of total energy consumption. Natural gas and coal accounted for an average of 24% and 23% of the total energy consumed, respectively. Most of the petroleum was consumed in the transportation end-use sector, the electricity power generators utilized the majority of coal and natural gas was largely consumed by the industrial and residential end-users.

Emissions of CO_2 from fossil-fuel combustion increased at an average annual rate of 1.6% from 1990 to 2000. The fundamental factors causing this trend were (1) a robust domestic economy, (2) relatively low energy prices as compared to 1990, (3) significant growth in

[1] Global Warming – Climate, (http://yosemite.epa.gov/oar/globalwarming.nsf/content/climate.html), US EPA, Washington, DC, July 2003.

[2] Climate Change: State of Knowledge, Office of Science and Technology Policy, Office of the President, October 1997.

emissions from transportation activities and electricity generation, and (4) heavier reliance on nuclear energy (leading to a lower rate of increase).

Relation of CO_2 to other global warming gases

CO_2 is the largest global warming gas in terms of relative tonnage emitted. However, quantity is not the only climate change factor. Each GHG has two additional factors that make them different. These factors are the **relative global warming potential** and the **atmospheric lifetime**. The global warming potential relates to the physical aspect of the gas, which determines its ability to reflect the proper wavelengths of light or heat energy to result in the allowance or disallowance of this energy to escape from Earth's atmosphere. In order to compare the relativity of each GHG to trap heat in the atmosphere, the IPCC commissioned by the United Nations to assess the scientific, technical, and socioeconomic information relevant for the understanding of the risk of human-induced climate change, developed a system referred to as the global warming potential (GWP). GWP's are defined using the warming effects relative to CO_2 as the baseline. For example, methane has a GWP of 21, which indicates it has a global warming potential of 21 times that of CO_2. This comparison is valid for only GHG with long atmospheric lifetimes, making them more likely to be evenly distributed throughout the atmosphere. Also, the GWP's are used to convert GHG emissions to units of million metric tons of carbon equivalent (MMTCE).[1]

Greenhouse gases of most concern are carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF_6). The first three are the most prominent and important in most analyses. Table A-1 contains relevant information on the three primary GHG.

Table A.1: Global atmospheric concentration (ppm), Atmospheric Lifetime (years) and Global Warming Potential of Selected Greenhouse Gases

Atmospheric Variable	CO_2	CH_4	N_2O
Pre-Industrial (1790) Concentration	278	0.700	0.270
1998 Atmospheric Concentration	365	1.745	0.314
Atmospheric Lifetime-years	50-200[a]	12[b]	114[b]
Global Warming Potential	1[c]	21[c]	310[c]

[a] No single lifetime can be defined for CO_2 because of the different rates of uptake by different removal processes.
[b] This lifetime has been defined as an "adjustment time" that takes into account the indirect effect of the gas on its own residence time.
[c] GWP's are calculated over a 100 year time horizon.

- **Methane** (CH_4) is a colorless and odorless hydrocarbon produced through anaerobic (without oxygen) decomposition of waste landfills, animal digestion, decomposition of animal wastes, production and distribution of natural gas, coal and oil production and

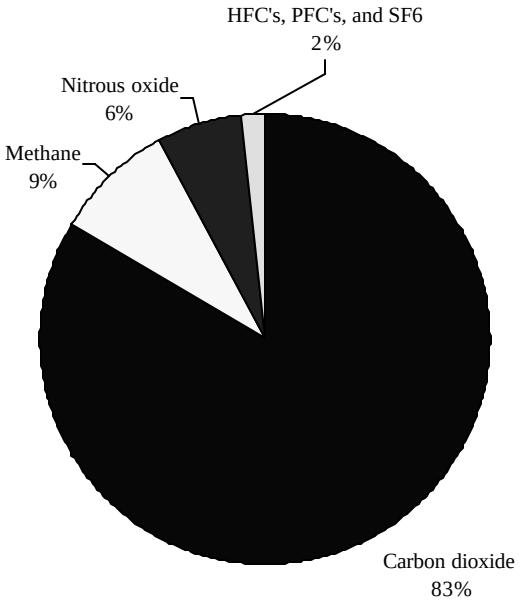
[1] Greenhouse Gases and Global Warming Potential Values, US EPA, Office of Atmospheric Programs, Washington, DC, April 2002.

incomplete fossil fuel combustion. As may be imagined, these sources proliferate in both the manmade and the natural environment.

- **Sulfur Hexafluoride** (SF_6) is a colorless gas utilized (in relatively small quantities) primarily in electrical transmission and distribution systems and in electronics. Often this gas is released in small quantities as a tracer in scientific atmospheric studies as it can be detected at very low levels and natural sources do not exist.
- **Perfluorocarbons** (PFCs) and **Hydroflurocarbons** (HFC's) are a group of man made chemicals composed only of carbon and fluorine. These chemicals were introduced as alternatives to certain ozone depleting substances. Additionally, perfluorocarbons and hydrofluorocarbons are emitted as by-products of industrial processes and used in manufacturing.
- **Nitrous Oxide** (N_2O) is emitted from farm soil (especially where commercial and organic fertilizers are used), fossil fuel combustion, nitric acid production and biomass combustion. Since N_2O is quickly oxidized to Nitrogen Dioxide (NO_2) in the atmosphere, it is normally estimated and presented as NOx. This pollutant (as emitted from coal fired utility boilers) is addressed by the controls imposed by the CSA.

The figure below illustrates the distribution of GHG by gas for 2000.[1]

Figure A.2: 2000 Greenhouse Gas Emissions by Gas



Review of these relative comparisons show that no simple relationship between the largest quantities of gas emitted in any given year and the predominant affecter of the resulting climate change phenomenon exist. Of course, one must not lose sight of the uncertainties

[1] Inventory of US GHG Emissions and Sinks 1990-2000,US EPA, Washington, DC, April 2002.

involved in all of these estimates. Though scientifically derived, the uncertainties are high, and it is difficult to make absolute and certain statements that can be defended without caveats and reservations.

Global Climatic Effects of Greenhouse Gases

Climate change refers to long-term fluctuations in temperature, precipitation, wind, and other elements of the Earth's climate system. The climate system can also be influenced by changes in the concentration of various gases in the atmosphere, which affect the Earth's absorption of radiation.[1] Under the United Nations Framework Convention on Climate Change (UNFCCC), the definition of climate change is " a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods." Given the following definition, IPCC concluded in its Second Assessment Report that:

> *Human activities are changing the atmospheric concentrations and distributions of greenhouse gases and aerosols. These changes can produce a radiative forcing by changing either the reflection or absorption of solar radiation, or the emission and absorption of terrestrial radiation.*

IPCC further concluded, "Concentrations of atmospheric greenhouse gases and their radiative forcing have continued to increase as a result of human activities." In the aftermath of the IPCC report, the National Academy of Sciences commissioned the National Research Council to review the IPCC report and identify areas of uncertainty in the science of climate change. Among the National Research Council findings were:

- Greenhouse gases are accumulating in the earth's atmosphere because of human activities, causing surface air temperatures and subsurface ocean temperatures to rise.
- Human induced warming and associated sea-level rises are expected to continue through the 21st century. Secondary effects are suggested by computer model simulations and basic physical reasoning. These include increases in rainfall rates and increased susceptibility of semi-arid regions to drought.
- The greater our emissions of greenhouse gases and the associated changes in climate, the more severe the adverse impacts of climate change will be.
- Because there is considerable uncertainty in current understanding of how the climate system varies naturally and reacts to emissions of greenhouse gases and aerosols, current estimates of the magnitude of future warming should be regarded as tentative and subject to future adjustments.

The Earth's surface temperature has risen by approximately 1 degree Fahrenheit over the past century with accelerated warming over the past two decades, according to the National Academy of Sciences. Global mean surface temperatures have increased 0.5 to 1.0° F since the late 19th century. The 20th century's ten warmest years all occurred in the last fifteen years of this century.[2] Warming of this magnitude can cause changes in temperature and precipitation patterns, induces sea level rise, and alters the distribution of fresh water supplies. Globally, sea

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[1] Climate Change: State of Knowledge, Office of Science and Technology Policy, Office of the President, October 1997.

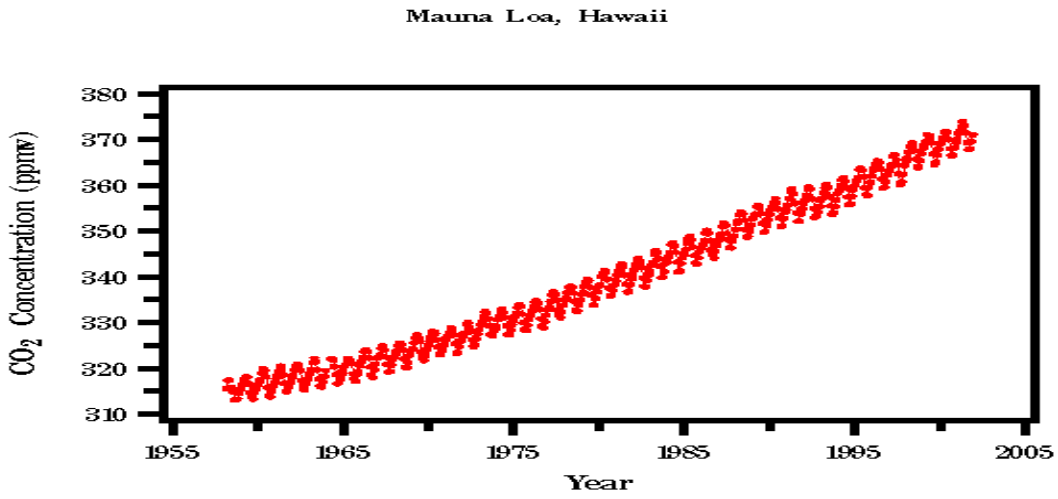
[2] Global Warming – Climate, US EPA, (http://yosemite.epa.gov/oar/globalwarming.nsf/content/index.html), July 2003

level has risen 4 to 10 inches over the past century and precipitation over land has increased by approximately 1%. Scientists expect that the average global surface temperature could rise 1 to 4.5° F in the next fifty years and 2.2 to 10° F in the next century. GHG have an atmospheric lifetime ranging from decades to centuries. The GHG currently being emitted will affect the climate well into the 21st century.

At Mauna Loa, Hawaii, atmospheric CO_2 measurements shown in Figure.A.3 constitute the longest continuous record of atmospheric CO_2 concentrations available in the world. The Mauna Loa site is considered one of the most favorable locations for measuring undisturbed air because possible local influences of vegetation or human activities on atmospheric CO_2 concentrations are minimal and any influences from volcanic vents may be excluded from the records. The methods and equipment used to obtain these measurements have remained essentially unchanged during the 44+-year monitoring program.

As Earth becomes warmer, the global water cycle speeds up. This is the exchange of water among the oceans, atmosphere, and land. Higher temperatures cause more evaporation, and soils dry out faster. Increased amounts of water in the atmosphere causes more rain or snow overall. Cold spells would still occur in the winter, but heat waves ill likely be more common. Some places will be drier and others wetter. Since the beginning of the century, precipitation in the U.S. has increased by about 6% and the frequency of intense precipitation (heavy downpours of more than two inches per day) has increased by 20%.[1] Such events can cause severe flooding. Between 1981 and 1991, the length of the growing season in the northern latitudes has been estimated to have increased by up to twelve days. "Greening" in spring and summer also have been estimated to occur up to eight days earlier than normal, and vegetation continued to photosynthesize about four days longer than "historically."

Figure A.2: Example of Ambient CO2 Concentration Trend[2]



Source: Dave Keeling and Tim Whorf (Scripps Institution of Oceanography)

[1] Climate Change: State of Knowledge, Office of Science and Technology Policy, Office of the President, October 1997.

[2] Carbon Dioxide Research Group, Scripps Institution of Oceanography, University of California, La Jolla, California, http://cdiac.esd.ornl.gov/trends/co2/sio-mlo.htm, 2003

A decrease in Northern Hemisphere snow cover, a decrease in Artic Sea ice, and continued melting of alpine glaciers, have also been corroborated. The global mean sea level has risen 4 to 10 inches over the last century, mainly because water expands when heated. Melting of glaciers, which has been measured worldwide over the last century, is believed to be a contributing factor to the rise in the sea level. Formerly frozen soils in the Alaskan and Siberian artic have begun the melt, damaging both the ecosystems and infrastructure. Melting and tundra warming will also lead to decay of organic matter and the release of trapped carbon and methane, thereby creating an additional source of GHG. Whether these are directly caused by man's activity is somewhat speculative, but they are certainly well correlated with the increases in GHG.

PREDICTIONS OF FUTURE CLIMATIC CHANGES

General circulation models are complex computer simulations that describe the circulation of air and ocean currents and how energy is transported with the climate system. Though still somewhat uncertain, these models provide powerful tools for studying climate. With such models, the developers and other scientists believe that a projected increase in the atmosphere's heat trapping ability for a given concentration of GHG has reasonable precision. However, the resulting impact on climate is more uncertain. This is primarily because the climate system is very complex and dynamic, with constant interaction between the atmosphere, land, ice, and oceans.

Such model calculations suggest that the global surface temperature could increase an average of 1.6 to 6.3^{o} F by 2100, with considerable regional variation. These temperature changes would be far greater than recent natural fluctuations, and they would occur faster than any known changes in the last 10,000 years with the US is expected to warm faster than the global average.

The models suggest that the rate of evaporation will increase as the climate warms, increasing average global precipitation. They also suggest increased frequency of intense rainfall as well as a marked decrease in soil moisture over some mid-continental regions during the summer. Using these model results, sea level is projected to increase between 6 and 38 inches by 2100. The frequency and intensity of some extreme weather of critical importance to ecological systems (droughts, floods, frosts, cloudiness, the frequency of hot or cold spells, and the intensity of associated fire and pest outbreaks) could increase.

Projections for North Carolina

Calculations and estimates of climate change are much less reliable at regional scales than globally. It remains unclear whether the regional climate will become more variable. In reports authored by EPA and researchers at Appalachian State University, a series of projections were compiled from various sources.[1] These projections are very uncertain, and in many cases are internally inconsistent and contradictory. Separating the "sky is falling" scenarios from those that are realistic in a shorter term (100 years) or those that will likely or plausibly happen over centuries is difficult to impossible. This does not mean that we should not take prudent actions

[1] Climate Change and North Carolina, EP 236-F-98-007q, US EPA, Climate and Policy Assessment Division, September 1998.

to mitigate the effects. Some of these projections are summarized below for purposes of completeness and reference.

Climatic Effects

Based on projections made by the IPCC and results from the United Kingdom Hadley Centre climate model (HadCM2), temperatures in North Carolina could increase by 3^{o} F (with a range of 1 to 5^{o} F) in all seasons. By the same measures, precipitation could increase by about 15% (with a range of 5 to 30%) in winter and spring and slightly more in fall and summer. Variations (swings) in wet and dry extremes are also predicted to increase. Recent reports with updates and testing of this model have been reported to indicate that revisions to model cause it to provide substantially different results. This information will be reviewed and updated in a future report.

Health Effects

Direct effects of ambient CO_2 in the atmosphere on the human body have not been shown and are not believed to be problematic. Of course, extremely high levels of CO_2 levels in breathing air could cause suffocation. However, the concerns for health as projected from high ambient levels and climate changes are more subtle and indirect. Levels found in smokestacks from coal-fired power plants do not approach the levels to make this a problem in ambient air.

Possible or likely indirect health effects from elevated GHG have been identified that are not related to direct mechanisms. With variable degrees of plausibility some of these speculations are outlined below:

- Some increases in heat related deaths and illnesses.
- Mosquito populations could possibly increase, thus increasing the potential for transmission of diseases.
- Increased duration, intensity, and extent of harmful algal blooms (red tides) and related bacterial growth.
- Possible (over time) decline (and/or migration) of various forest and vegetative species northward.[1]

Water Resources

Increased precipitation could help alleviate water supply problems and provide more water for dilution of pollutants. However, projections[2] indicate there could also be increased flooding. Other projections made in these reports include:

- Higher rainfall could increase erosion and exacerbate levels of pesticides and fertilizers in runoff from agricultural mining and urban areas.
- Higher stream flows could intensify problems in low-lying coastal areas and recent developments in floodplains.
- Lower flows and higher water temperatures (from the increased irregularity of "dry" times) also could degrade water quality by concentrating pollutant levels and reducing the assimilation of wastes.

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[1] Climate Change: State of Knowledge, Office of Science and Technology Policy, Office of the President, Washington, DC, October 1997.

[2] Ibid Reference 1.

- Aquifers in the Coastal Plains could be diminished further under the drought scenario predictions that occur because of the variable conditions predicted in the model.

Agriculture

Climatic conditions and water availability influence the mix of crop and livestock production. The list of speculations below is typical:

- As climate warms, production patterns could shift northward.
- Increases in climate variability could make adaptation by farmers more difficult.
- Increases in heavy rainfall episodes could increase erosion.
- Warmer climates and less soil moisture (Note uncertainty and apparent conflict with previous projection of higher rainfall) because of increased evaporation may increase the need for irrigation. The updated model may provide improved information.
- Decreased water supplies, again from the variability predicted by the models.

Coastal Areas

Sea level rise could lead to flooding of low-lying property, loss of coastal wetlands, erosion of beaches, saltwater contamination of drinking water, and decreased longevity of low-lying roads, causeways, and bridges. In addition, sea level rise could increase vulnerability of coastal areas to storms and associated flooding.

Forests

Trees and forests are adapted to specific climate conditions. As climate becomes warmer and drier (or wetter), forests change. Such changes may include:

- Species composition
- Geographic range
- Health and productivity
- Types of trees dominating those forests.[1]

Ecosystems

Valuable ecosystems in North Carolina, include spruce-fir forests, bogs, and un-vegetated hilltops in the mountainous regions; bottomland hardwood forests and fire-maintained prairies in the piedmont; and longleaf pine forests, provide critical habitat for numerous native plants and animals. The Great Smoky Mountains are recognized as a center for biodiversity. The southern Appalachians also contain a diverse array of salamanders, which are very sensitive to climatic changes. In addition to climatic changes, air pollution (acid rain and ground-level ozone) and exotic pests (hemlock wooly adelgid) already threaten the Appalachian spruce-fir forests.[2] Climatic changes could result in significant changes in these ecosystems.

- Warmer temperatures could lead to reduced stream flow and warmer water temperatures, which could impair fish reproduction.
- Increases in average temperatures could also reduce the distribution and limit the range of some fish species.

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[1] Climate Change and North Carolina, EP 236-F-98-007q, US EPA, Climate and Policy Assessment Division, Washington, DC, September 1998.

[2] Ibid Reference 1

- In coastal habitats, rising sea levels could inundate,
- Salinization may increase, and
- Sedimentation of vital wildlife habitats may occur.
- These effects will likely include further inland penetration of saltwater with many streams and rivers affected.

UNCERTAINTY

No estimate or projection is certain. This is especially true with projected consequences of global warming and climate change. Science can be certain that something is happening and may be able to measure some of its attributes. Due to randomness, known and unknown variables, and the immensity of the volume of global gases and landmass, no one can say that they know all the answers with an unquestionable degree of certainty. Debate continues on climate change and global warming, by scientists on each side of the issue that appear to have appropriate credentials. Nevertheless, the National Academy of Sciences, and the IPCC, internationally are the recognized bodies of leading scientists on the topic, and they have declared that global warming is already happening and that it is caused by human activities, mainly the burning of fossil fuels, which produces CO_2 and other GHG pollution. Thus, this is generally the conclusion that the DAQ recognizes as having the most credibility, and the one that prudent decisions should be based upon, at least until proven to be faulty. The approaches of these studies will be focused on when and how to achieve these goals, rather than if they should be goals.

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