CHAPTER 1

INTRODUCTION

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Overview

Global warming is an accepted scientific phenomenon. What is not well known is how much of the current climate change is attributable to humans and their activities and how much is part of the earth's natural climatic cycles. There is extensive scientific evidence, however, that greenhouse gases (GHGs) generated through the combustion of fossil fuels and through anaerobic action involving organic matter are contributing to the warming trend, if not driving it outright.

Of the GHGs, carbon dioxide (CO_2), methane (CH_4), and nitrous oxides (N_2O) are the three most prevalent. GHGs allow sunlight to penetrate the atmosphere as shortwave light energy. Upon reaching the earth's surface, the energy is transformed to longwave heat energy, which traps the heat and warms the atmosphere. Although a large source of GHGs is the natural processes involved in volcanic eruptions, organic decay, and animal digestion, human activities are responsible for nearly doubling the atmospheric concentration of CO_2 equivalent (eCO_2) from its pre-Industrial levels.

In an effort to reduce GHG emissions and to mitigate their effects, the United States has participated in several world conferences dealing with global climate change. The most recent conference was held in 1997 in Kyoto, Japan, where most industrial countries of the world tentatively agreed to lower their GHG productions. Negotiators for the United States tentatively agreed to a 7% reduction below its 1990 emissions level between 2008 and 2012. Increasing worldwide interest in global warming has led North Carolina and other states to begin devising their own plans to reduce GHGs. However, the Kyoto Protocol has not yet been ratified by the United States.

States are playing more of an active role in climate change research and planning than ever before and government officials are realizing that proactive action on their part may reduce GHG emissions in their states. Although the federal government has not issued any mandates yet, future agreements may encourage or even require states to implement reduction and mitigation strategies to reduce GHGs. More than 20 states have developed or have committed to producing state level action plans to reduce GHG emissions.

This plan, ***North Carolina's $ensible Greenhouse Gas Reduction $trategies,*** is designed by North Carolinians to make good economic sense, to utilize both old and new emissions reduction strategies and technologies, and to involve greater efficiencies and conservation to reduce emissions. Rather than wait upon any future agreements, that may or may not take into consideration the uniqueness of North Carolina's landscape, resources, society, and economy, the researchers in this study consulted with a cross-section of North Carolinians to develop a plan customized to fit the State.

Global Climate Change

As the science of global climate change is becoming widely accepted and debated less and less, countries are studying policies and economic costs of GHG reduction and mitigation strategies. The 1992 Rio Earth Summit resulted in the adoption of the Framework Convention on Climate Change that was signed by over 160 countries. In that summit, the United States tentatively committed to reducing GHG emissions to below 1990 levels by the year 2010, mostly by voluntary measures, pending U.S. Congressional approval. The 1997 Kyoto Conference on Climate Change proposed emission reduction targets for the United States and other countries. The Clinton Administration has concluded that use of flexible reduction mechanisms could enable the United States to reduce GHGs to 7 % below 1990 emissions by 2010, at a relatively modest cost. (For a more detailed discussion of the Kyoto Accords, see Vignettes 1-1 and 1-2. For a detailed discussion of background issues related to North Carolina's GHG emissions reductions, see Appendix A.)

Vignette 1-1
Kyoto Protocol and the United States
In December 1997, industrialized and developing countries met at the Kyoto Conference on Climate Change and negotiated an agreement for binding targets for reductions of six principal GHGs: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), sulfur hexafluoride (SF_6), perfluorocarbons (PFCs) and hydrofluorocarbons (HFCs). While industrialized countries tentatively accepted binding emissions targets, the developing countries did not subscribe to similar targets. The Clinton Administration continues to request greater participation by developing countries. In a July 1998 report, the Clinton Administration emphasizes the flexibility and low cost in achieving the negotiated target reduction (Executive Office of the President 1998). Although it is difficult to analyze the costs and benefits of mitigating climate change, the Clinton Administration report suggests that the mitigation costs could be $7-12 billion per year in 2008 to 2012, or 0.1 percent of projected gross domestic product (GDP). The report forecasts costs for mitigation measures of modest increases of 4 to 6 cents per gallon of gasoline and between $70 and $100 for the average household's annual energy bill. According to the report, these figures do not include either the economic benefits or the potential for other domestic policies to reduce costs and GHGs (Executive Office of the President 1998).

The target reduction could be achieved in terms of an average over a five-year period, between 2008 and 2012, and allows for "banking" of emissions reductions. Including all six GHGs in the target allows reductions in one gas to be used as a substitute for increases in others. Additionally, the inclusion of "sink" activities such as reforestation, enhances the flexibility of the target for the United States. The most important tool for achieving emissions reduction goals allows international emissions trading and joint implementation among countries, as well as allowing countries or businesses to earn credits for projects in the developing countries that reduce emissions (Executive Office of the President 1998). However, the United States is forecasted to increase its eCO_2 levels by more than 30% between 1990 and 2012 (Brown et al 1998).

The United States' commitment has been problematic for Congressional approval, in part, because of the lack of reduction targets for developing countries. The U.S. Senate passed the Byrd-Hagel resolution 95-0 that made commitment by developing countries to emission targets a prerequisite for ratifying the Kyoto treaty. The U.S. government maintains that developing countries must have meaningful participation because of the global nature of the problem, the rapid increases in emissions in those countries, and the lower costs to reduce emissions in developing countries. The United States' position now seems to be at a standstill until these issues are resolved, perhaps at the next international convention.

Vignette 1-2

Impacts of Global Warming

Although some disagreement exists in the scientific community, most climate scientists anticipate real risks from global climate change. Most scientists agree that this century is the hottest since at least AD 1400 and that the nine hottest years, since record keeping began in the late 19th century, have all occurred since 1987 (Quayle et al. 1998, Karl 1998). In fact, the year 1998 has the dubious honor of being the hottest year on record since record keeping began in the 1860s (Office of Science and Technology Policy 1999). The Intergovernmental Panel on Climate Change (IPCC) concluded that the global mean land surface temperature has increased 0.45-0.6°C (0.8-1.0°F) in the last century. Although estimates vary, the IPCC estimates that global temperatures will increase by a range of 1.8 to 6.3 degrees F, with an estimate of 3.6 degrees F, by the year 2100. These increases are projected not due to natural causes, but rather because of human activities, mainly the burning of fossil fuels and deforestation (IPCC 1996a). Further evidence of warming can be found on the national scale. According to Karl et al. (1995), temperatures in the United States have increased slightly during the last century despite local or regional episodes of cooling (Saxena 1999).

Economists maintain that the economic costs from damages caused by global warming could cost the U.S. economy $55 billion to $111 billion in the year 2060 (Cline 1992). The countries of the world are realizing that GHGs have a long life and that governmental decisions and actions will have major impacts regarding the reduction of

GHGs. Prompt action may be required because the costs of increased GHGs could be enormous to reduce in the future.

Policymakers may choose to be cautious about taking steps to reduce GHGs due to the scientific uncertainties and mitigation costs. Admittedly, the questions about climate change are numerous, including the timing, size of the problem, and possible results. However, taking steps to reduce GHGs, while balancing social and economic needs can be a win-win situation. In a 1992 report, the National Academy of Sciences stated that "...even given the considerable uncertainties in our knowledge of the relevant phenomena, greenhouse warming poses a potential threat sufficient to merit prompt responses...Investment in mitigation measures act as insurance protection against the great uncertainties and the possibility of dramatic surprises" (National Research Council 1992,17-21). Supporters of immediate mitigation steps also provide the following rationale: immediate action is more feasible and effective than later actions, mitigation measures may too late if delayed until all climate change facts are known, insurance against possible disaster is wise, irretrievable errors should be avoided, high-risk environmental experiments are unwise, costs and benefits arguments do not include environmental goods, and mitigation measures can be rationalized as producing additional environmental benefits (National Research Council 1992).

Potential negative impacts from a warming climate may be numerous and serious. As the rate of evaporation increases because of global warming, the world will likely experience more frequent and intense floods, droughts, and hurricanes. Sea level rises of between 6 and 38 inches are projected by the year 2100 (Office of Science and Technology Policy 1997). This increase could result in salinization of the water supply of coastal communities and inundation of coastal properties. Health-related effects to communities could be significant, with increases in malaria, schistosomiasis and other infectious diseases, as well as an increase in deaths due to extreme heat. Other potential negative consequences of global climate change could include higher rates of respiratory illnesses, changing weather effects on agriculture, increased crop losses due to insects and diseases, changes to the aquatic food chain and stresses on natural ecosystems (IPCC 1996b).

Many of these climate change effects could also occur in our State. In North Carolina, a drier, warmer climate system could require changes in agricultural products and practices. A higher demand for electricity to power air-conditioning could result from significant increases in the number of days with temperatures greater than 90 degrees F and even 100 degrees F. In terms of adverse effects to human health, increased heat stress in the state would take its toll on the elderly and the very young (0-4 years). With 804,341 persons, or 12.1% of the total population age 65 and older in the 1990 census, North Carolina has a large percentage of older residents who may be affected. A total of 458,955 residents, or 6.9% of the total population, were less than 5 years in the *1990 Census of Population and Housin*g. Increased problems with respiratory disorders and allergic respiratory disorders could result from climate warming. Since Charlotte, the Triad area, Raleigh-Durham, and most recently Asheville, already post ozone warnings in the summer, a decrease in air quality could exacerbate problems and even fatalities for respiratory disorder sufferers.

Changes to the ecosystem and natural resources, a major draw for tourism, could also prove disastrous to the state. A major contributor to the state's healthy economy, the North Carolina coastline could experience climate changes that would result in substantial economic costs. Salinization of water supply, stronger and more frequent hurricanes, and inundation of coastal properties would likely hurt the state's coastal building boom and tourism. Studies show that a 1-cm sea level rise will result in beach recession of 2 m along the Carolinas (IPCC 1998).

The Atmospheric Warming Process

Energy from the sun heats the Earth's surface and drives our weather and climate; in turn, the earth radiates energy back into space. Atmospheric GHGs (water vapor, carbon dioxide, methane, chlorofluorocarbons and other ozone depleting compounds, and nitrous oxides) trap some of the outgoing energy, retaining heat similar to the glass panels of a greenhouse. These gases are useful, because without this natural "greenhouse effect," temperatures on earth would be much lower, and life would not be possible (Karl 1993). Due to the warming actions of GHGs, the earth's average temperature is a hospitable 60°F. Problems may develop, however, when the atmospheric concentration of GHGs increases. Since the beginning of the Industrial Revolution, concentrations of GHG emissions have increased approximately 25%, and current trends will lead to a doubling by the end of the next century (IPCC 1990). In recent years, major concern with global warming and climate change has centered on anthropogenic-induced changes in the gaseous and particulate composition of the atmosphere (IPCC 1995).

The primary GHGs are carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), and water vapor (H_2O). In addition, there are a number of other gases which are emitted by human technologies in relatively small quantities, but which are particularly powerful agents of global warming. These include ozone depleting chlorofluorocarbons (CFCs and HCFC's), hydrofluorocarbons (HFC's), perflurocarbons (PFC's), and sulfur hexafluoride (SF_6). Finally, there are a number of trace gases and air pollutants that have minor impacts on the atmosphere's balance of radiation, including carbon monoxide (CO), sulfur dioxide (SO_2), nitrogen oxides (NOx), ozone (O_3), and non-methane volatile organic compounds (NMVOCs) (Turco 1995; WDNR 1993).

This focus of this study is confined to the three primary GHGs – CO_2, CH_4 and N_2O. As a naturally occurring atmospheric gas, water vapor is not included. Ozone depleting CFC's and HCFC's (whose primary use is in air conditioning systems) are covered by the Montreal Protocol for protection of the ozone layer. Future analyses of North Carolina GHG reduction strategies should consider including HFC's, PFC's and SF6, as they are covered by the Kyoto Protocol. They have not been included here for lack of inventory data, and their net contribution to North Carolina's GHG emissions is considered to be very small (on the order of one percent). As for the other trace gases, they are not covered by the Kyoto Protocol and they make only a minor contribution to the climate change process (Turco 1995).

Dynamics of North Carolina's GHG Emissions

In 1990, North Carolina emitted 145 megatons of eCO_2 (recalculations of data from Appalachian State University 1996). (See Chapter 3.) Using a slightly revised and updated version of this inventory more fully described in the next chapter, this study projects North Carolina's GHG emissions will grow to 216.1 megatons by 2010 under a "business-as-usual" scenario. These eCO_2 projections were based upon historical energy consumption data from the United States Energy Information Administration (USEIA) *State Energy Data Report, 1996* (1999), macroeconomic indicators and energy use found in the DRI/McGraw-Hill *North Carolina Energy Outlook* (1996), Standard & Poor's DRI, *North Carolina Energy Outlook, 1998* (1999), and population and economic data in the Woods & Poole *1997 State Profile* (North Carolina) (1997). Based on this projection, to meet a proposed North Carolina target of reducing emissions to 7 % below 1990 eCO_2 emissions, the state will need to reduce its annual emissions by 81.1 megatons by the year 2010, to 135 million tons.

Organization of the Study

This study proposes strategies that will reduce eCO_2 emissions by 81.1 million tons by approaching each sector of the state's economy. The sectors can be divided into those that are energy-user sources and those that are non-energy sources of GHGs. Among the energy-user sectors are residential, industrial, commercial, transportation, and electric power utilities. Emissions from electricity generation are considered both from the perspective of the end users of electricity and from the perspective of the electricity supply system. Agriculture and waste are the primary sources of non-energy GHGs (especially CH_4 methane and N_2O).

The forestry sector is a special case. Although the forestry industry uses a minimal amount of energy, a growing forest absorbs carbon dioxide from the atmosphere and sequesters it as carbon in the forest trees and soils, thereby acting as a GHG "sink." According to the Kyoto Protocol, only carbon dioxide absorption in excess of what was already occurring in 1990 may be counted as a "sink," and so there is no contribution from forestry in the 1990 base year inventory used in this analysis. We do, however, include the contribution that a growing forest "sink" can have on mitigating North Carolina's GHG emissions by the year 2010.

Chapter 2 describes the method used for the analysis, and includes a description of a new version of a database model developed by Torrie Smith Associates to inventory state GHG emissions and evaluate strategies and measures. This model is based on a version developed for the International Council for Local Environmental Initiatives (ICLEI) for use by local governments in developing GHG emission reduction strategies. A secondary objective of this study has been to develop simplified methods for conducting state inventories and emission reduction strategies. The ICLEI model has been adapted for use in this analysis and recommendations are made for how it could further adapted for use by North Carolina and other State governments in developing strategies and tracking results. This innovative model allows strategies to be tested to determine their potential impacts on GHG reduction and cost savings.

Chapter 3 presents an overview of North Carolina's present and forecast GHG emissions and provides additional detail on the forecasting methods used in this study. This chapter sets the stage for each of the following sector chapters by discussing and comparing the sectors' contributions to the state's total GHG bundle.

Chapter 4 deals with the industrial energy use and potential savings, particularly dealing with fuel switching, co-generation, and heat loss.

Chapter 5 analyzes the commercial sector's energy use, specifically involving increasing floor space issues, heating and cooling efficiencies, and lighting.

Chapter 6 looks at the residential sector, specifically analyzing housing energy use, efficiencies, and savings strategies and measures in both existing and new residences.

Chapter 7 is an assessment of potential for energy use and GHG reductions in the transportation sector. The chapter is divided into strategies and measures that can be taken by users and those that may be initiated by market forces or mandated by governments.

Chapter 8 assesses potential efficiencies in the utilities sector. In order to eliminate the potential for double counting in the other sectors' analyses, this chapter deals only with efficiencies that the utilities can implement, such as generation efficiency improvements, fuel switching and the adoption of renewable sources of electricity.

Chapter 9 deals with non-energy GHG emissions issues in the agriculture sector. Animal manure management, the capture of CH_4 from waste lagoons, and more efficient applications of nitrogen fertilizer are the principal issues.

Chapter 10 analyzes non-energy GHG reduction strategies and measures dealing with landfill waste. Examples of successful efforts to capture CH_4 from landfills are given to encourage development of other such landfill sites. The GHG benefits of waste reduction and recycling are also considered here.

Chapter 11 assesses strategies to increase forest area to provide additional potential sink for carbon. Although there are many strategies dealing with long-term carbon sequestration potential in wood products, that goes beyond the scope of this project. We propose expansion of forestland as an important strategy for increasing the carbon sink in North Carolina.

Finally, a compilation of the impacts of all the sector scenarios is presented in Chapter 12, showing the mix of measures that will be required for North Carolina to meet a proposed target of bringing emissions down to 93% of their 1990 levels by the year 2010.

Conclusions

We believe that this plan is only the beginning and that it provides our leaders and ourselves with a fundamental blueprint. We also believe that new technologies, agreements, and societal behaviors will develop additional useful reduction strategies in the future. It behooves all of us to be conservative in the use of our resources, to use them frugally and not extravagantly, and to save some for future generations. We owe that to our children.

This plan takes all of this into consideration. It just makes good North Carolina $ense.

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