North Carolina

Climate Action Plan Advisory Group (CAPAG)

Recommended Mitigation Options for Controlling Greenhouse Gas Emissions

Final Report
October 2008

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Preface

This report contains recommendations from a voluntary stakeholder advisory group on potential measures to reduce greenhouse gas (GHG) emissions that are worthy of consideration by policy makers in North Carolina. This advisory group represents a broad range of interests in North Carolina. The Climate Action Plan Advisory Group (CAPAG) consists of more than 40 volunteers from business, industry, environmental groups, academia, government and the general public. A consultant, the Center for Climate Strategies (CCS), provided facilitation and technical analysis expertise. From over 300 potential GHG mitigation options, more than 50 were analyzed considering likely GHG reductions, costs and benefits.

The North Carolina General Assembly created a Legislative Commission on Global Climate Change (LCGCC) in the fall of 2005 to address climate related issues. These issues included whether North Carolina should set a goal for reduction of GHGs in this state, and if so, what that goal should be. CAPAG coordinated closely with the LCGCC and shared several members with that Commission.

This report is not intended to be a climate action implementation plan for North Carolina. Such a plan will come only after State policy makers assess these and other recommendations further. However the data, results and recommendations contained in this report provide valuable guidance for the creation of an action plan(s) for legislative, administrative, regulatory or voluntary action.

The Appalachian State University (ASU) Energy Center and CCS and their team of analysts worked together to conduct a secondary economic impact analysis of the potential economic and jobs impacts of various options developed by the CAPAG. The ASU Energy Center examined thirty of the fifty-six mitigation options bundled into twenty- three mitigation option scenarios with similar policies grouped together for analysis. Combined, these options account for more than 90% of the GHG emissions reductions and offsets identified by the CAPAG.

For the study, the ASU Energy Center utilized the NC Energy Scenario Economic Impact Model (NC ESEIM). Originally developed in 2005 for the North Carolina Energy Policy Council, the peer-reviewed model assesses the impacts of various energy policies on the North Carolina economy, measured in terms of employment, employee and proprietor compensation (income), and the incomes earned by labor and capital (gross state product). The results and discussion of the secondary economic impact analysis are summarized in Chapter 1 of the CAPAG report. The results and the report methodology are discussed in detail in a separate report entitled, "Secondary Economic Impact Analysis of Greenhouse Gas Mitigation Options for North Carolina" available at "http://www.ncclimatechange.us" or "http://daq.state.nc.us/monitor/eminv/gcc."

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The CAPAG also recognizes the many individuals who participated in the sector-based Technical Work Groups, all of whom are listed in Appendix B. Even though this report is intended to represent the results of the CAPAG's work, the group would be remiss if it did not recognize and express appreciation for the time and efforts spent in discussion, study, and deliberation of each fellow member of the group.

Finally, the CAPAG would like to thank the donor organizations that provided the financial support to CCS that allowed it to serve the CAPAG: NC DENR, Energy Foundation, Rockefeller Brothers Fund, Surdna Foundation, and Z. Smith Reynolds Foundation.

Members of the North Carolina Climate Action Plan Advisory Group[1]

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Lisa Riegel, NC Natural Heritage Trust Fund

Roger Sheats, Global Warming Initiatives

Paul Sherman, NC Farm Bureau (replaced Mitch Peele)

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[1] **Note:** A limited number of members of the CAPAG were members in the beginning, but due to job changes, etc., were later replaced by others representing the same company. Their participation and contributions are acknowledged and appreciated even though they were not on the Group for its full existence.

Larry Shirley, State Energy Office, NC Department of Administration
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Stephen Whitfield, NC Woodlands
Jim Witkowski, International Paper (replaced Edward Kruel)
Skip Yeakel, Volvo Trucks North America

Acronyms

AC	alternating current
ACEEE	American Council for an Energy-Efficient Economy
AEO	Annual Energy Outlook
AFW	Agriculture, Forestry, and Waste Management [TWG]
AG	Attorney General
AIA	American Institute of Architects
AQ	air quality
ASAP	Appliance Standards Awareness Project
ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers
ASU	Appalachian State University
ASUEC	Appalachian State University Energy Center
AVL	automatic vehicle location
B20	blend of 20% biodiesel and 80% petroleum diesel
BACT	Best Available Control Technology
BAU	business as usual [assuming no major changes to reduce greenhouse gases]
BCAP	Building Code Assistance Project
BenMAP	Environmental Benefits Mapping and Analysis Program
Btu	British thermal unit
C&D	construction and demolition
c/kWh	cents per kilowatt hour
CALS	College of Agriculture and Life Sciences [NCSU]
CAPAG	[North Carolina] Climate Action Plan Advisory Group
CARB	California Air Resources Board
CBECS	Commercial Buildings Energy Consumption Survey
CC	Cross-Cutting Issues [TWG]
CCS	Center for Climate Strategies
CCSR	carbon capture and storage/sequestration or reuse
CCV	closed crankcase ventilation [on buses and trucks]
CDG	customer-operated distributed generation
CEFS	Center for Environmental Farming Systems [North Carolina Department of Agriculture and Consumer Services]
CERT	Community Emergency Response Team
CH_4	methane
CHP	combined heat and power
CNG	compressed natural gas
CNR	College of Natural Resources [NCSU]

CO	carbon monoxide
CO_2	carbon dioxide
CO_2e	carbon dioxide equivalent
COBRA	Co-benefits Risk Assessment [Model]
COG	Council of Governments
CPCN	Certificate of Public Convenience and Necessity
CREP	Conservation Reserve Enhancement Program [USDA]
CRP	Conservation Reserve Program [USDA]
CS	Cambridge Systematics, Inc.
CSA	Clean Smokestacks Act [of 2002]
CTIC	Conservation Technology Information Center
DAQ	[North Carolina] Division of Air Quality
DC	direct current
DCM	[North Carolina] Division of Coastal Management
DENR	[North Carolina] Department of Environment and Natural Resources
DG	distributed generation
DMV	[NCDOT] Division of Motor Vehicles
DOA	[North Carolina] Department of Administration
DOC	diesel oxidation catalyst
DOR	[North Carolina] Department of Revenue
DPF	diesel particulate filter [for buses and trucks]
DPI	Department of Public Instruction
DPPEA	[North Carolina] Division of Pollution Prevention and Environmental Assistance
DSM	demand-side management
DVD	digital versatile disc [formerly digital video disc]
E10	blend of 10% ethanol and 90% gasoline
E85	blend of 85% ethanol and 15% gasoline
EE	energy efficiency
EEM	Energy Efficient Mortgage [Initiative]
EF	emission factor
EIA	Energy Information Administration [US DOE]
EMC	Environmental Management Commission
EPRI	Electric Power Research Institute
EPS	environmental portfolio standard
EQIP	Environmental Quality Incentives Program [USDA]
ERC	Environmental Review Commission
ES	Energy Supply [TWG]

ESEIM	Energy Scenario Economic Impact Model
ESI	Environmental Stewardship Initiative
EV	electric vehicle
FDP	[North Carolina] Forest Development Program
FERC	Federal Energy Regulatory Commission
FFV	flexible-fuel vehicle
FIA	Forest Inventory Analysis
FPP	Farm Preservation Program
FSA	Farm Service Agency [USDA]
FTA	Federal Transportation Administration
FY	fiscal year
GHG	greenhouse gas
GIS	geographic information system
GMAC	General Motors Acceptance Corporation
GPS	global positioning systems
GREET	Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation [Model]
GWh	gigawatt-hours
GWP	global warming potential
HB	House Bill
HBH	HealthyBuilt Homes [Program]
HC	hydrocarbon
HDV	heavy-duty vehicle
HFC	hydrofluorocarbon
HVAC	heating, ventilation, and air conditioning
HWP	harvested wood products
I&F	Inventory and Forecast
IAQ	indoor air quality
IEBC	International Existing Building Code
IECC	International Energy Conservation Code
IES	Industrial Extension Service
IGA	investment grade audit
IGCC	integrated gasification combined cycle
IPCC	Intergovernmental Panel on Climate Change
IR/E	idle reduction/elimination
IRS	Internal Revenue Service
IT	information technology
kWh	kilowatts per hour

LCGCC	[North Carolina] Legislative Commission on Global Climate Change
LCID	land clearing and inert debris [landfills]
LDV	light-duty vehicle
LEED	Leadership in Energy and Environmental Design
LEED-H	Leadership in Energy and Environmental Design for Homes
LFG	landfill gas
LFGTE	landfill gas to energy [sometimes LFGE]
LIREP	Low-Income Residential Energy Program
LMOP	Landfill Methane Outreach Program
LPG	liquefied petroleum gas
MH	manufactured home
MMBtu	million British thermal units
MMt	million metric tons
MMtC	million metric tons of carbon
$MMtCO_2e$	million metric tons of carbon dioxide equivalent
MST	municipal sewage treatment
MSW	municipal solid waste
MW	megawatt
N_2O	nitrous oxide
NASA	National Aeronautics and Space Administration
NC	North Carolina
NCA&T	North Carolina Agricultural & Technical State University
NCCES	North Carolina Cooperative Extension Service
NCDA&CS	North Carolina Department of Agriculture and Consumer Services
NCDFR	North Carolina [DENR] Division of Forest Resources
NCDOT	North Carolina Department of Transportation
NCGP	North Carolina GreenPower
NCHFA	North Carolina Housing Finance Agency
NCSC	North Carolina Solar Center
NCSTEP	North Carolina Small Town Economic Development
NCSU	North Carolina State University
NCUC	North Carolina Utilities Commission
NEED	National Energy Education Development [Project]
NEMA	National Electrical Manufacturers Association
NEMS	National Energy Modeling System
NESCAUM	Northeast States for Coordinated Air Use Management
NG	natural gas
NO_x	nitrogen oxides

NPV	net present value
NRCS	Natural Resource Conservation Service [USDA]
NREL	National Renewable Energy Laboratory [US DOE]
O&M	operations and maintenance
PAYD	Pay-As-You-Drive
PBF	Public Benefits Fund
PC	performance-based contracting
PEM	polymer electrolytic membrane [fuel cells]
PFC	perfluorocarbon
PHA	Public Housing Authority
PIRG	Public Research Interest Group
PM	particulate matter
PSCNC	Public Service Company North Carolina
PTD	Public Transportation Division [NCDOT]
PV	photovoltaic
R&D	research and development
RCI	Residential, Commercial, and Industrial [TWG]
RDU	Raleigh-Durham [Airport]
REC	renewable energy credits
RESNET	Residential Energy Services Network
RFF	Resources for the Future
RFP	request for proposals
RFS	renewable fuel standard
ROI	return on investment
RPS	renewable portfolio standard
RTD	Regional Transportation District [bus rapid transit]
RTI	Research Triangle Institute
SB	Senate Bill
SEO	State Energy Office
SEP	State Energy Plan
SEQL	Sustainable Environment for Quality of Life
SERC	Southeastern Electric Reliability Council
SF_6	sulfur hexafluoride
SIT	State Greenhouse Gas Inventory Tool [US EPA]
SM	service mark (similar to a trademark)
SMEs	small and medium enterprises
SO_2	sulfur dioxide
SOV	single-occupancy vehicle

SUV	sport utility vehicle
SWCD	[North Carolina] Soil and Water Conservation District
SWH	solar water heating
t	metric ton (1,000 kg or 2,205 lb.)
T&D	transmission and distribution
TCR	*The Climate Registry*
TDM	Transportation Demand Management [Program]
TLU	Transportation and Land Use [TWG]
TMO	Transportation Management Organization
TRC	total resource cost
TSE	truck stop electrification
TWG	Technical Work Group
UNC	University of North Carolina
UNCA	University of North Carolina-Asheville
UNCG	University of North Carolina-Greensboro
UPS	uninterruptible power supply
US DOE	U.S. Department of Energy
US EPA	U.S. Environmental Protection Agency
USDA	U.S. Department of Agriculture
USFS	U.S. Forest Service
USI	Utility Savings Initiative
VAC	volts alternating current
VMT	vehicle miles traveled
WARM	WAste Reduction Model [US EPA]
WHIP	Wildlife Habitat Incentives Program [USDA]
WRP	Waste Reduction Partners
ZEH	Zero Energy Home

Executive Summary

Introduction

In 2002, the North Carolina General Assembly passed, and the Governor signed, the Clean Smokestack Act (CSA). The CSA tasked the North Carolina Department of Environment and Natural Resources' (DENR) Division of Air Quality (DAQ) with studying options for reducing carbon dioxide (CO_2) emissions from coal-burning power plants and other sources. The Act required DAQ to complete a series of studies and make recommendations for reducing North Carolina's carbon emissions.[1, 2, 3] As a result of these studies, DAQ and DENR embarked on efforts to further address the potential reductions of North Carolina's greenhouse gas (GHG) emissions. The DAQ recognized that many potential options that would mitigate GHG emissions also likely have the long term potential to stimulate economic growth and create much needed jobs in the state, regardless of, and in addition to impacts upon climate change.

The final CSA report, submitted to the North Carolina General Assembly in September of 2005, contained a recommendation, that the state continue GHG mitigation planning to consider a public stakeholder process. Thus, the North Carolina Climate Action Plan Advisory Group (CAPAG) was initiated within an open and publicized process to develop recommendations to DENR/DAQ. The purpose was to assemble a diverse group of stakeholders to further identify and assess mitigation options that might be appropriate, carry out analysis and make recommendations that state policy makers should consider for a state-level Climate Action and Implementation Plan. This report provides the results of that process, focusing in addition to GHG reductions on economic opportunities impacts and co-benefits as associated with proposed potential mitigation options.

The CAPAG process was organized by first assembling 43 stakeholders to represent a diverse range of interests and expertise. The CAPAG met seven times from February, 2006 through October, 2007. During this same period, five technical work groups (TWGs) of the CAPAG developed initial recommendations in the areas of: Energy Supply (ES); Residential, Commercial, Industrial (RCI); Transportation and Land Use (TLU); Agriculture, Forestry, and Waste Management (AFW); and Cross-Cutting Issues (CC). These TWGs consisted of both a consultant facilitator and expertise for analysis as well as several experts and interested parties from within each of the sector communities. The membership of the CAPAG and the five TWGs are documented elsewhere in the appendices of this report. The CAPAG followed a consensus-building process designed and facilitated by the non-profit Center for Climate Strategies (CCS). Applying a proven design similar to those used elsewhere, CCS provided both facilitation services and technical analysis to the CAPAG in formulating its recommendations.

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[1] CO_2 Emission Reduction Options For Coal-fired Electrical Utility Boilers and Other Stationary Sources, First Interim Report, NC DENR/DAQ, Raleigh, NC, September 1, 2003.

[2] CO_2 Emission Reduction Options For Coal-fired Electrical Utility Boilers and Other Stationary Sources, Second Interim Report Pursuant to Clean Smokestacks Act, NC DENR/DAQ, Raleigh, NC, September 1, 2004.

[3] Recommended Carbon Dioxide (CO_2) Emission Reduction Strategies for North Carolina (Pursuant to North Carolina's Clean Smokestacks Act of 2002), NC DENR/DAQ, Raleigh, NC, September 1, 2005.

The North Carolina General Assembly in 2005 also formed the Legislative Commission on Global Climate Change (LCGCC) with a charge to among other things, determine if a cap on emissions was warranted, and if so, at what level should it be set. The LCGCC appointed by leaders of both the House and Senate and facilitated by Legislative Counsel and staff, held its first meeting on February 3, 2006. Though the Commission has focused mainly on broader issues, the CAPAG has coordinated closely with them and has become integrated in many of their deliberations.

CAPAG Mitigation Option Recommendations and Impacts

The CAPAG offers 56[4] recommended options for further study and potential adoption that are believed to be most important for mitigating North Carolina's GHG emissions. The level of support among CAPAG members for these options, although not always unanimous, has been very high. As a starting point it was discovered that

- GHG emissions as estimated subsequent to a 1990 baseline have grown at a rate much higher than most areas due to the growth in population and high level of prosperity in this state, as further detailed later in the report. This growth has resulted in large increases in use of electricity, more cars driving more miles, and other consumer trends that have developed.

- Projected emissions can be reduced significantly if each and every one of the CAPAG's recommendations is completely, strictly and properly implemented and the estimated reductions are fully achieved.

- Full adoption by the state and complete, strict and proper implementation of each and every one of the CAPAG's recommendations is estimated to reduce gross GHG emissions by approximately 47%, from 256 million metric tons of carbon dioxide equivalent ($MMtCO_2e$) in the reference case forecast to 137 $MMtCO_2e$ by 2020, or within 1% of 1990 levels.

- Cumulative GHG reductions from 2007-2020 from complete adoption and implementation are estimated to be as high as 828 $MMtCO_2e$.

- The associated economic analysis (considering both plus and minus costs) indicates significant cost savings for the State's economy over the period 2007–2020.

The associated cost savings are defined fully in the following chapters of this report.

Details of the 56 mitigation options and their analysis, over the five sectors, as supported by the CAPAG process and recommendations are presented in Chapters 3 through 7 of this report, and in the Appendices.

As further discussed in Chapter 1, the CAPAG's recommendations complement efforts underway in North Carolina, especially the LCGCC and policies and programs developed by the

[4] This number is based on the total number of options approved by the CAPAG (see table below). Some options were renumbered (i.e., AFW-7 to AFW-4b; TLU 2 to TLU-1b) or combined (e.g., AFW 9&10), and others were divided into sections a, b, c to yield a total of 56 options supported by CAPAG.

North Carolina Energy Office.[5] This report also points to numerous co-benefits that would result from implementation of CAPAG-recommended options.

As this is currently a very active area, we also note that the State Energy Office is currently updating the State Energy Plan. In addition, during the 2007 session of the General Assembly, State Legislators adopted, and Governor Easley signed, several bills related to mitigation options also considered by the CAPAG, particularly relating to a requirement for North Carolina utilities to use renewable energy and energy efficiency programs and to require the state to increase energy efficiency in existing and new state-owned and leased buildings. Time and resources have not allowed a full integration of these actions into the recommendations included in this report. A summary of the CAPAG's 56 Mitigation Options by sector is provided below:

Mitigation Option Name		Cumulative GHG Reductions 2007–2020 $MMtCO_2e$
	Residential, Commercial, and Industrial (RCI)	
RCI–1	Demand Side Management Programs for the RCI Sectors - Recommended Case: "Top-Ten States" EE Investment	77.1
RCI–2	Expand Energy Efficiency Funds	54.8
RCI–3	Energy Efficiency Requirements for Government Buildings	6.4
RCI–4	Market Transformation and Technology Development Programs	10.5
RCI–5	Improved Appliance and Equipment Efficiency Standards	5.3
RCI–6	Building Energy Codes	23.1
RCI–7	"Beyond Code" Building Design Incentives and Targets, Incorporating Local Building Materials and Advanced Construction	34.2
RCI–8	Education (Consumer, Primary/Secondary, Post-Secondary/ Specialist, College and University Programs)	Not Applicable (NA)
RCI–9	Green Power Purchasing (required for state facilities) and Bulk Purchasing Programs for Energy Efficiency or Other Equipment	3.5
RCI–10	Distributed Renewable and Clean Fossil Fuel Power Generation	33.5
RCI–11	Residential, Commercial, and Industrial Energy and Emissions Technical Assistance and Recommended Measure Implementation	14.9
	SECTOR TOTAL AFTER ADJUSTING FOR OVERLAPS	218.7
	RCI REDUCTIONS FROM RECENT ACTIONS*	10.1
RCI–1	Demand Side Management Programs for the Residential, Commercial and Industrial Sectors	6.2
RCI–2	Expand Energy Efficiency Funds	3.6
RCI–6	Building Energy Codes	0.0
RCI–9	Green Power Purchasing (required for state facilities) and Bulk Purchasing Programs for Energy Efficiency or Other Equipment	0.3
	SECTOR TOTAL PLUS RECENT ACTIONS	228.8

[5] See Annex A to Appendix E (Residential, Commercial and Industrial Sectors) for summaries of the North Carolina State Energy Office (SEO) and State Energy Plan (SEP) policies and programs related to RCI mitigation options.

Mitigation Option Name		Cumulative GHG Reductions 2007–2020 $MMtCO_2e$
	Energy Supply (ES)	
ES-1	Renewable Energy Incentives	0.33
ES-2	Environmental Portfolio Standard	
ES-2a	Original Analysis	288.7
ES-2b	20% Combined Target	166.2
ES-2c	Load Growth Offset Target	160.3
ES-3	Removing Barriers to CHP and Clean DG	20.1
ES-4	CO_2 Tax and/or Cap-and-Trade	
ES-4a	Electric Sector Only	20.4
ES-4b	Economy-wide	47.7
ES-5	Legislative Changes to Address Environmental and Other factors	NA
ES-6	Incentives for Advanced Coal	
ES-6a	Replacement of New 800 MW Pulverized Coal Plant	31.0
ES-6b	Replacement of Existing 800 MW Pulverized Coal Plant	42.9
ES-7	Public Benefit Charge	24.4
ES-8	Waste to Energy	0.02
ES-9	Incentives for CHP and Clean DG	NA
ES-10	NC GreenPower Renewable Resources Program	0.95
	SECTOR TOTAL AFTER ADJUSTING FOR OVERLAPS	375
	REDUCTIONS FROM RECENT ACTIONS (None)	0
	SECTOR TOTAL PLUS RECENT ACTIONS	375
	Transportation and Land Use (TLU)	
TLU-1a	Land Development Planning	58.2
TLU-1b	Multi-Modal Transportation and Promotion (formerly TLU-2)	52.4
TLU-3a	Surcharges to Raise Revenue	15.7
TLU-3b	Rebates/ Feebates to Change Fleet Mix	2.8
TLU-4	Truckstop Electrification	NA
TLU-5	Tailpipe GHG Standards	44.5
TLU-6	Biofuels Bundle	35.4
TLU-7	Procure Efficient Fleets	NA
TLU-8	Idle Reduction/Elimination Policies	2.2
TLU-9	Diesel Retrofits	13.5
TLU-11	Pay-As-You Drive Insurance	42.0
TLU-12	Advanced Technology Incentives	NA
TLU-13	Buses – Clean Fuels	NA
	SECTOR TOTAL AFTER ADJUSTING FOR OVERLAPS	232.3
	REDUCTIONS FROM RECENT ACTIONS (None)	0
	SECTOR TOTAL PLUS RECENT ACTIONS	232.3

Mitigation Option Name		Cumulative GHG Reductions 2007–2020 $MMtCO_2e$
	Agriculture, Forestry, and Waste (AFW)	
AFW-1	Manure Digesters & Energy Utilization	6.4
AFW-2	Biodiesel Production (incentives for feedstocks and production plants)	5.1
AFW-3	Soil Carbon Management (including organic prod. methods incentives)	3.0
AFW-4a	Preservation of Working Land–Agricultural Land	2.6
AFW-4b	Preservation of Working Land–Forest Land (formerly AFW-7)	36
AFW-5	Agricultural Biomass Feedstocks for Electricity or Steam Production	0.2
AFW-6	Policies to Promote Ethanol Production	38
AFW-8	Afforestation and/or Restoration of Nonforested Lands	15
AFW-9&10	Expanded Use of Forest Biomass and Better Forest Management	48
AFW-11	Landfill Methane and Biogas Energy Programs	20
AFW-12	Increased Recycling Infrastructure and Collection	4.1
AFW-13	Urban Forestry Measures	34
	SECTOR TOTAL AFTER ADJUSTING FOR OVERLAPS	213
	REDUCTIONS FROM RECENT ACTIONS (None)	0
	SECTOR TOTAL PLUS RECENT ACTIONS	213
	Cross-Cutting Issues (CC)	
CC-1	GHG Inventories and Forecasts	NA
CC-2	GHG Reporting	NA
CC-3	GHG Registry	NA
CC-4	Public Education and Outreach	NA
CC-5	Adaptation	NA
CC-6	Options for Goals or Targets (for CAPAG in support of LCGCC)	NA

Some options were renumbered (i.e., AFW-7 to AFW-4b; TLU 2 to TLU-1b) or combined (e.g., AFW 9&10), and others were divided into sections a, b, c to yield a total of 56 options supported by CAPAG.

* “Recent actions" represent initiatives undertaken in North Carolina that reduce GHG emissions that were implemented shortly before or during the CAPAG process. The emission reductions associated with recent actions are not accounted for in the GHG emissions inventory and reference case projections. Emissions reductions associated with these recent actions were therefore estimated separately, and are counted toward overall statewide reductions along with reductions from the mitigation options recommended by the CAPAG.

Perspectives on Mitigation Option Recommendations

There can be a large variation in the GHG reductions associated with various options. These are discussed in substantially more detail in the following chapters and appendices, as well as details of the costs, cost per ton, figures showing the net reductions, and other details of how the information was developed.

Secondary Economic Impact Analysis of Mitigation Options

The Appalachian State University (ASU) Energy Center and CCS and their team of analysts worked together to conduct a secondary economic impact analysis of the potential economic and jobs impacts of various options developed by the CAPAG. The ASU Energy Center examined thirty of the fifty-six mitigation options bundled into twenty-three mitigation option scenarios with similar policies grouped together for analysis. Combined these options account for more than 90% of the GHG emissions reductions and offsets identified by the CAPAG.

For the study, the ASU Energy Center utilized the NC Energy Scenario Economic Impact Model (NC ESEIM). Originally developed in 2005 for the North Carolina Energy Policy Council, the peer-reviewed model assesses the impacts of various energy policies on the North Carolina economy, measured in terms of employment, employee and proprietor compensation (income), and the incomes earned by labor and capital (gross state product).

On the whole, implementation of the modeled mitigation option bundles would result in a mildly positive economic impact on North Carolina's economy. By 2020, the mitigation options analyzed would result in the creation of more than 15,000 jobs, $565 million in employee and proprietor income, and $302 million in gross state product. For the study period, 2007–2020, the mitigation options analyzed would generate more than $2.2 billion net present value (NPV) in net additional employee and proprietor income and more than $1.2 million (NPV) in net gross state product. These results and the report methodology are discussed in substantially more detail in the following chapters and the ASU Energy Center's stand-alone report available at "http://www.ncclimatechange.us" or "http://daq.state.nc.us/monitor/eminv/gcc."

Chapter 1
Background and Overview

The Climate Action Planning Initiative

North Carolina leaders, including the General Assembly, have acted upon concerns that North Carolina would be prudent to examine steps that could and should be taken to address climate change and any man made components of the problem. The concerns include potential that the state's vast coastal areas and other resources may suffer damage from climate changes. In 2002 the North Carolina General Assembly passed, and the Governor signed, a major bill, commonly known as the Clean Smokestack Act (CSA), that is resulting in major reductions in sulfur dioxide (SO_2) and oxides of nitrogen (NO_x) emissions from coal-fired power plants.

The CSA also charged the North Carolina Division of Air Quality (DAQ) with studying and reporting on potential controls for carbon dioxide (CO_2) emissions from coal-fired electric power plants. This resulted in a series of reports with recommendations for reducing North Carolina's carbon emissions. One of those recommendations was to develop a climate action plan. Under the CSA's Section 13 requirements, the Division released a draft inventory and forecast of the state's GHG emissions as well as the third report (September 2005) with a list of recommendations assembled by the Division.

The Center for Climate Strategies (CCS), a non-profit organization with expertise and a history of similar efforts regarding greenhouse gas (GHG) emissions, prepared the draft inventory and forecast under contract and through donated funds. The Center also made recommendations on a process which would result in a prioritized list of GHG mitigation options. Following the publication of the September 2005 report, the North Carolina Department of Environment and Natural Resources (DENR) with management supplied by the DAQ, initiated a follow up to that report and began the first steps toward a comprehensive climate action plan by commencing a facilitated stakeholder process to consider potential mitigation options.

During this period, the state General Assembly also established the Legislative Commission on Global Climate Change (LCGCC, or "the Commission") to assess GHG concerns and, among other things, provide a recommendation to the General Assembly regarding whether the state should establish a cap on emissions, and if so, what that cap should be. The Commission held its first meeting in February 2006 and initiated a climate-related fact-finding effort regarding the science and potential recommendations. The DAQ (assisted with support from CCS) was asked to provide technical background and implementation support to the work of the LCGCC. This cooperative effort was initiated and is expected to continue through the Commission's life, currently proposed to be extended until October 2009.

DAQ recognized that it was possible, and even likely, that many potential GHG mitigation options would stimulate economic growth and new jobs in the state, in addition to reducing the effects of climate change. Thus, a stakeholder process was initiated which called on over 40 volunteer stakeholders representing a broad range of interests and expertise to be formed into a body to be called the Climate Action Plan Advisory Group (CAPAG). This diverse group of North Carolina citizens, representing business, industry, environmental and educational

organizations and government, took on the responsibility of analyzing and making recommendations for priority options to reduce GHG emissions in the state. Many of the CAPAG members were also members of the LCGCC. Their work included:

- Development, prioritization, analysis and approval of a final collection of existing and proposed actions that could contribute to GHG emissions reductions.
- Review and approval of an inventory of historical and forecasted GHG emissions in North Carolina as a basis against which to gauge priorities and progress.
- Consideration of costs and emission reductions of recommended options.

This report is the outcome of that effort, one that involved a distinguished and broad group of stakeholders including other state agencies, with technical support and facilitation from the CCS.

Recent Developments

North Carolina has undertaken several efforts to conserve energy while addressing GHG emissions. The North Carolina State Energy Office has developed and is currently updating the State Energy Plan.[1] Examples of efforts undertaken by other entities include the following:

- *Major utilities in North Carolina have expanded existing demand-side management programs (DSM) for the RCI sectors.*
- *Under the authority of the North Carolina Utilities Commission, a Public Benefits Charge is collected on electricity sales, a portion of which is managed by the Advanced Energy Corporation and used to fund energy efficiency and economic development programs.*
- *NC GreenPower coordinates a voluntary program of green power purchasing for consumers in the governmental, residential, commercial and industrial sectors.*
- *The state fleet of vehicles has been required (and this requirement continues to expand) to meet several standards goals related to make the fleet Flex-fueled and to increase the purchase of hybrid and other high mileage/low emitting vehicles.*

In addition, during 2007 the North Carolina General Assembly considered several bills related to mitigation options that were also considered by the CAPAG. The following includes legislation passed by the General Assembly and signed by the Governor. Note that the CAPAG had completed analysis of its mitigation options before the final requirements of these bills were determined. As a result, the GHG reductions and costs (or cost savings) reflected in this report have not been aligned specifically with these new statutes.

- Senate Bill (SB) 3 (Promote Renewable Energy/Energy Efficiency) includes the following:
    - Requires a percentage of energy sales in North Carolina to come from new renewable sources and efficiency measures on the following schedule: 3% by 2012 (up to 0.75%

[1] See Annex A to Appendix E (Residential, Commercial and Industrial Sectors) for summaries of the North Carolina State Energy Office (SEO) and State Energy Plan (SEP) policies and programs related to RCI mitigation options. Also note that that plan is now being updated.

from efficiency); 6% by 2015 (up to 1.5% from efficiency); 10% by 2018 (up to 2.5% from efficiency); and 12.5% by 2021 (up to 5% from efficiency).

  - Requires specific amounts of electricity sales from: (1) solar (0.02% in 2010 up to 0.2% in 2018); (2) swine waste (0.07% in 2012 up to 0.2% in 2018); and (3) poultry waste (170,000 megawatt hours in 2012 up to 900,000 megawatt hrs in 2014.
  - Requires any new biomass energy facility to meet Best Available Control Technology (BACT). Other language was included to ensure that renewable energy technologies do not have secondary, undesirable consequences. Impacts on residential consumers must not exceed $10 per year 2008-2011; $12 per year 2012-2014; and $34 per year 2015 and beyond.
  - Allows for ongoing review of construction costs for new power plants and recovery of costs in a general rate case.

- SB 567 (Allow Distribution of E-Blend Fuels) - Allows E85 to be dispensed from dispensers approved for E10 provided the manufacturer has initiated the process for approval by an independent testing lab.
- SB 1272 (Definition of Biodiesel) - An individual that produces biodiesel for use in a private (non-commercial) vehicle is exempt from the motor fuels tax.
- SB 1277 (State Diesel Vehicles' Warranties/B20 Fuel) - Every new diesel vehicle purchased by the State shall be covered by an express manufacturer's warranty that allows the use of B20 fuel.
- SB 1452 (Diesel School Buses to Use Minimum B20 Fuel) - Requires that 2% of the annual diesel used by North Carolina school buses be B20 by June 2008 (2% = ~ 500,000 gallons).
- SB 668 (Energy Conservation in State Buildings) - Energy Conservation in State Buildings – Specific performance criteria and goals for sustainable, energy efficient public buildings must be established.
- SB 670 (Energy Devices That Use Renewable Resources) - Use of Solar Collectors on detached single-family residences – As long as they aren't facing public access or common areas, an ordinance, deed restriction, covenant and other similar agreements cannot prohibit or have the effect of prohibiting their installation.

The CAPAG Process

The CAPAG first met in February of 2006 and was charged with making recommendations to DAQ that would then be a resource list and as input to further state consideration and proposals for action. The CAPAG met seven times with the final decisional meeting held in July 2007. In addition a meeting to review this report's capture of the intent of the members of CAPAG was held in October 2007. This report addresses comments provided at that meeting and shortly thereafter. In all, about 75 meetings and significant conference calls of the CAPAG and their supporting technical work groups (TWGs) were held between February 2006 and July, 2007 to identify and analyze various potential mitigation actions.

The CAPAG was assisted and supported by, five TWGs representing local and outside expertise in key sectors selected for analysis: Energy Supply (ES); Residential, Commercial, Industrial

(RCI); Transportation and Land Use (TLU); Agriculture, Forestry, and Waste Management (AFW); and Cross-Cutting Issues (CC). The TWGs consisted of CAPAG members as well as individuals not on the CAPAG with interest and expertise in the issues being addressed by each TWG. CAPAG members as well as individuals not on the CAPAG with interest and expertise in the issues being addressed formed each TWG. Where members of the TWG did not fully agree upon recommendations to the CAPAG, the summary of their efforts was reported to the CAPAG for their further consideration and actions. (See Appendix B for a listing of the members of each group.)

The CAPAG process involved a model of informed self-determination through a facilitated stepwise consensus building approach. Under the oversight of DENR, the process was conducted by the CCS, an independent, expert facilitation and technical analysis team. It was based on procedures that CCS consultants have used in a number of other state climate change planning initiatives since 2000, but adapted specifically for North Carolina. The CAPAG process sought, but did not mandate consensus, and it explicitly documented the level of CAPAG support for individual mitigation options and key findings established through a voting process, outlined and agreed to in advance.

The 56 top priority (out of over 300 total) recommendations adopted by the CAPAG and presented in this report underwent two levels of screening by the CAPAG. First, a potential mitigation option being considered by a TWG was not accepted as a "priority for analysis" and developed for full analysis unless it had a supermajority of support from CAPAG members present at the decisional meetings (with a "supermajority" defined as 80% or more of the CAPAG members attending a meeting agree). Second, after the analyses were conducted, only options that received at least majority support from CAPAG members present at the decisional meetings were adopted by the CAPAG and included in this report. In total, of the 56 recommended mitigation options adopted by the CAPAG, more than 85% (48) received unanimous consent, and just over 14% (8) received a majority of support, of those present at the CAPAG decisional meetings. The TWGs recommendations to the CAPAG were documented and presented to the CAPAG at each CAPAG meeting. All meetings were open to the public, were widely advertised, and all materials for and summaries of the CAPAG and TWG meetings were posted on the project website.

Analysis of Options

With CCS providing facilitation and technical analysis, the TWGs prepared mitigation options for CAPAG consideration using a "mitigation option template" conveying key information:

- Mitigation option description
- Mitigation option design (goals, timing, parties involved)
- Implementation mechanisms
- Related policies / programs in place
- Type(s) of GHG reductions
- Estimated GHG reductions and costs (or cost savings)

- Key uncertainties
- Additional benefits and costs
- Feasibility issues
- Status of group approval
- Level of group support
- Barriers to consensus

In its deliberations, the CAPAG modified and embraced various mitigation options. The final versions for each sector, conforming to the mitigation option templates, appear in Appendices E through I and constitute the most detailed record of decision of the CAPAG. Appendix D presents a description of the methods used for quantification of mitigation options. CCS and the TWGs produced estimates of the GHG emission reductions and costs (or cost savings) of various mitigation options, both in terms of a net present value from 2007-2020 and a dollars-per-ton cost (i.e., cost-effectiveness).[2] The key methods are summarized here:

- *Estimates of GHG reductions.* Using the projection of future GHG emissions (see below) as a starting point, analysis of the impact of mitigation options produced estimates of the GHG reductions attributable to each option in the years 2010 and 2020, and cumulative over the time period 2007-2020. Many options were estimated to affect the quantity or type of fossil fuel combusted; others affected methane (CH_4) or CO_2 sequestered, etc. Among the many assumptions involved in this task was selection of the appropriate GHG accounting framework, namely, the choice between taking a "production-based" approach versus a "consumption-based" approach to various sectors of the economy.[3] The CAPAG took a "production-based" approach in all sectors except the electricity sector, in both forecasting emissions and in estimating the GHG impacts of mitigation options. This issue, along with other GHG estimation issues (e.g., analysis of overlapping or interacting mitigation option impacts), are discussed in detail in Chapter 2 (GHG Inventory and Reference Case Projections), Appendix D (Methods for Quantification), and Chapters 3 through 6 and Appendices E through H for each sector.
- *Estimates of costs or cost savings.*
    - *Discounted and Annualized Costs.* Standard approaches were taken here. The "present value" of costs was calculated by applying a real discount rate of 5%. Dollars-per-ton estimates were derived as an annualized cost per ton, dividing the "present value cost" by the cumulative GHG reduction measured in tons. As was the case with GHG reductions, the period 2007-2020 was analyzed.

[2] The analysis addressed emission reductions and associated cost or cost savings and did not attempt to estimate specific price changes or utility rate changes that might result from implementation of a mitigation option.

[3] In brief, a production-based approach estimates GHG emissions associated with goods and services produced within the state, and a consumption-based approach estimates GHG emissions associated with goods and services consumed within the state. In some sectors of the economy, these two approaches may not result in significantly different numbers, however, the power sector is notable in that it is responsible for large quantities of GHG emissions, and states often produce far more or far less electricity than they consume (with the remainder attributable to power exports or imports). North Carolina imports electric power and must account for the emissions this consumption creates, even though they are not produced in-state.

- *Cost savings.* Many options created easily monetized cost savings (e.g., fuel savings and electricity savings). In these cases, monetized cost savings were subtracted from monetized costs, resulting in net costs. These net costs could be positive or negative; negative costs indicated that the option saved money or produced "cost savings."
- *Direct vs. Indirect Effects.* Estimates costs and cost savings were based on "direct effects" (i.e., those borne by the entities implementing the option).[4] Implementing entities could be: individuals, companies, and/or government agencies, etc. In contrast, conventional cost-benefit analysis takes the "societal perspective" and tallies every conceivable impact on every entity in society (and quantifies these wherever possible).
- *North Carolina vs. National/Global perspective.* Estimates costs and cost savings were based on implementing entities in North Carolina, not on a broader societal perspective (national or global). One implication of this is that national taxes or subsidies that affect actions in North Carolina were not part of the analysis.

- *Contributing issues.* The CAPAG recommendations were guided in part by the GHG reductions and monetized costs and cost savings of various options, but members also felt that other considerations should also have weight. The CAPAG developed a checklist for TWGs to use to keep in mind important human, social, economic, environmental, and other factors that may warrant consideration when evaluating GHG emission reduction strategies. The TWGs were asked to examine these qualitative terms where deemed important, and quantify them on a case-by-case as needed depending on need and where data were readily available.

North Carolina GHG Emissions Inventory and Reference Case Projections

In support of requirements to the CSA and in cooperation with DENR, CCS prepared a draft document, entitled *Revised Draft North Carolina Greenhouse Gas Inventory and Reference Case Projections 1990–2020* (hereafter *Inventory and Projections*).[5] The projection of future emissions aimed to capture as accurately as possible the trajectory of emissions given policies and programs in place as of 2004. The draft was presented to the CAPAG at its first meeting, and then approved by unanimous consent at the CAPAG's fifth meeting following technical review and revision.[6] The *Inventory and Projections* included detailed coverage of all economic sectors and GHGs in North Carolina, including future emissions trends and assessment issues related to energy, economic, and population growth. The assessment included estimates of total statewide

[4] "Additional benefits and costs" were defined as those borne by entities other than those implementing the option. These indirect effects were quantified on a case-by-case basis depending on magnitude, importance, need and availability of data.

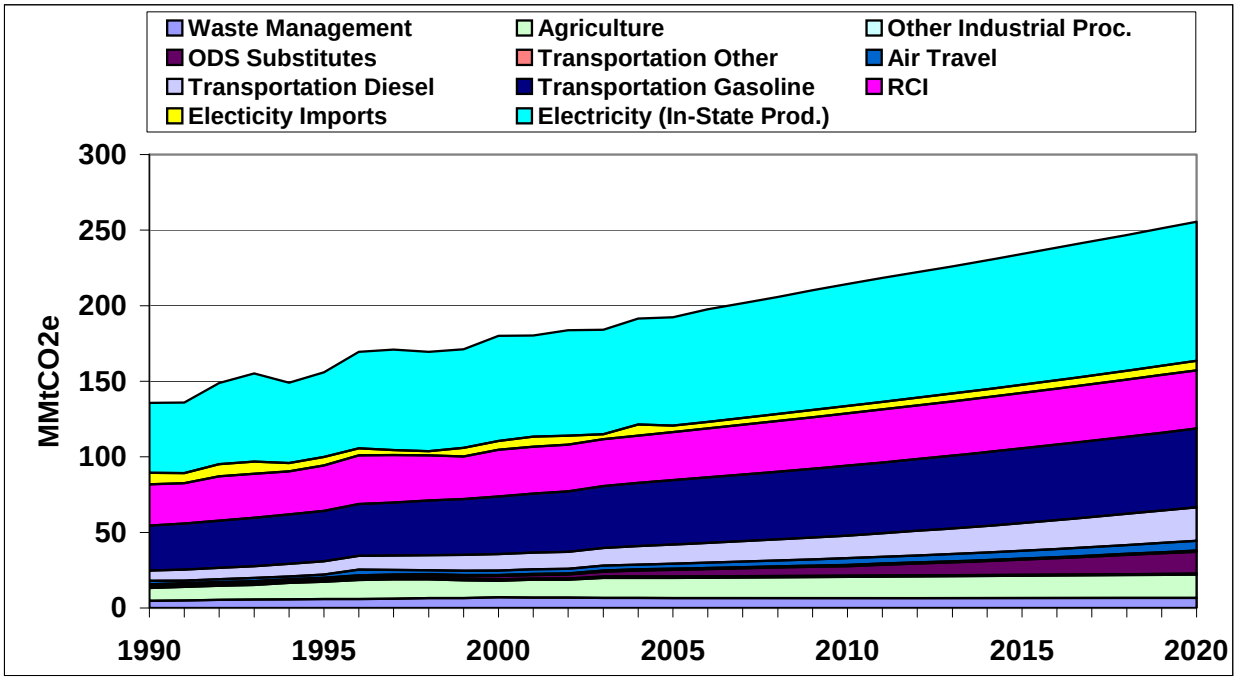
[5] *Revised Draft North Carolina Greenhouse Gas Inventory and Reference Case Projections 1990-2020*, prepared by the Center for Climate Strategies for the North Carolina DENR/DAQ, February 2006, http://www.ncclimatechange.us or http://daq.state.nc.us/monitor/eminv/gcc.

[6] *Final North Carolina Greenhouse Gas Inventory and Reference Case Projections 1990-2020*, prepared by the Center for Climate Strategies for the North Carolina DENR/DAQ, September 2007, http://www.ncclimatechange.us or http://daq.state.nc.us/monitor/eminv/gcc.

"gross emissions" (leaving aside carbon sequestration[7]) and "net emissions" (in which reductions due to sequestration are subtracted from gross emissions) on a production basis for all sources and a consumption basis for the electricity sector (see prior discussion under "Analysis of Options" in this chapter for an explanation of the production versus consumption approach). Further discussion of the issues involved in developing the inventory and reference case projections is summarized in Chapter 2 (Inventory and Projections of GHG Emissions) and discussed in detailed in the final report for the *Inventory and Projections*.

The *Inventory and Projections* revealed substantial emissions growth rates and related mitigation challenges. Figure 1-1 shows the reference projections for North Carolina's gross GHG emissions (not counting sequestration) as rising fairly steeply to 256 $MMtCO_2e$ by 2020, growing by 88% over 1990 levels. Figure 1-1 also provides the sectoral breakdown of forecasted GHG emissions. Accounting for sequestration in North Carolina's forests and soil would decrease the gross estimates from 23 to 24 $MMtCO_2e$ per year. On a net emissions basis (using the consumption-based approach), North Carolina's GHG emissions grow by about 106% over 1990 levels (about 232 $MMtCO_2e$ in 2020).

Figure 1-1. Gross GHG Emissions by Sector, 1990-2020: Historical and Projected (Consumption-based Approach) Business as Usual/Base Case



[7] Sequestration refers to the storing of carbon in mines, brine strata, oceans, plants and soil. As trees and other plants grow they remove CO_2, the principal GHG, from the atmosphere transforming the carbon (C) through photosynthesis into cellulose, starch and sugars, thus sequestering it in their structures and roots. The oxygen (O_2) is released back into the atmosphere. North Carolina's forests and agricultural lands are capable of sequestering much CO_2, as described in Chapter 6 (Agriculture, Forestry and Waste Management).

The inventory and projection of North Carolina's GHG emissions provided several critical findings, including:

- As is common in many states, the electricity and transportation sectors are the two sectors with the largest emissions, and are expected to continue to grow faster than other sectors.
- Consumption of electricity is growing faster in North Carolina than population. In addition, there appears to be a trend toward an increasing reliance on natural gas and imported electricity. Vehicle-miles traveled (VMT) are also projected to grow faster than the state's population. Freight traffic (resulting in increased diesel consumption) and increasing use of hydrofluorocarbons (HFCs) and perfluorocarbons (PFCs) as substitutes for ozone-depleting substances (ODS) in refrigeration, air conditioning, and other applications is also increasing more rapidly than population.

While North Carolina's emissions estimated growth rate (88% from 1990 to 2020 on a gross emissions, consumption basis) presents challenges, it also provides major opportunities. Key choices on technologies and infrastructure can have a significant impact on the emissions of a fast-growing state. The CAPAG's recommendations document the opportunities for the state to reduce its GHG emissions while continuing its strong economic growth by being more energy efficient, using more renewable energy sources, and increasing the use of cleaner transportation modes, technologies, and fuels. The inventory and reference case projections are discussed in more detail in Chapter 2 of this report and the entire study appears in the final report for the *Inventory and Projections*.[8]

Overview of CAPAG Mitigation Option Recommendations

The CAPAG offers 56[9] recommended options to DENR for mitigating North Carolina's GHG emissions. Among the CAPAG members that attended each decisional meeting, the level of support for these options is very high; 86% (48 options) received unanimous consent, and 14% (8 options) received a super majority. Figure 1-2 below presents:

- Projected growth in North Carolina's gross GHG emissions on a consumption basis (blue line). The consumption based approach accounts for emissions associated with the generation of electricity in-state and imported from out-of-state to meet North Carolina's demand for electricity.
- Projected emissions <u>if each and every one</u> of the CAPAG's recommendations is completely, strictly and properly implemented and the estimated reductions are fully achieved (green line).

[8] Detailed documentation of the inventory and reference case projections is provided in Final North Carolina Greenhouse Gas Inventory and Reference Case Projections, 1990-2020, prepared by the Center for Climate Strategies for the North Carolina DENR/DAQ, September 2007, http://www.ncclimatechange.us or http://daq.state.nc.us/monitor/eminv/gcc.

[9] This number is based on the total number of options approved by the CAPAG (see Table 1-3). Some options were renumbered (i.e., AFW-7 to AFW-4b; TLU 2 to TLU-1b) or combined (e.g., AFW 9&10), and others were divided into sections a, b, c to yield a total of 56 options supported by CAPAG.

As the figure illustrates, full adoption by the state and complete, strict and proper implementation of each and every one of the CAPAG's recommendations are projected to reduce gross GHG emissions (consumption basis) by approximately 47%, from 256 million metric tons of carbon dioxide equivalent ($MMtCO_2e$) in the reference case forecast to 137 $MMtCO_2e$ by 2020. Implementation of CAPAG's recommendations would thus be estimated to reduce North Carolina's gross GHG emissions to within 1% of 1990 levels by 2020. Table 1-1 provides the numeric estimates underlying Figure 1-2. Table 1-3 shows the estimated GHG reductions; costs or savings from each option; and, its cost effectiveness (cost or savings per ton of reduction). Detailed descriptions and analysis of these options are presented in Chapters 3 through 7 of this report, and in the Appendixes.

Figure 1-2. Annual GHG Emissions: Reference Case Projections and CAPAG Recommendations (Consumption-Basis, Gross Emissions)

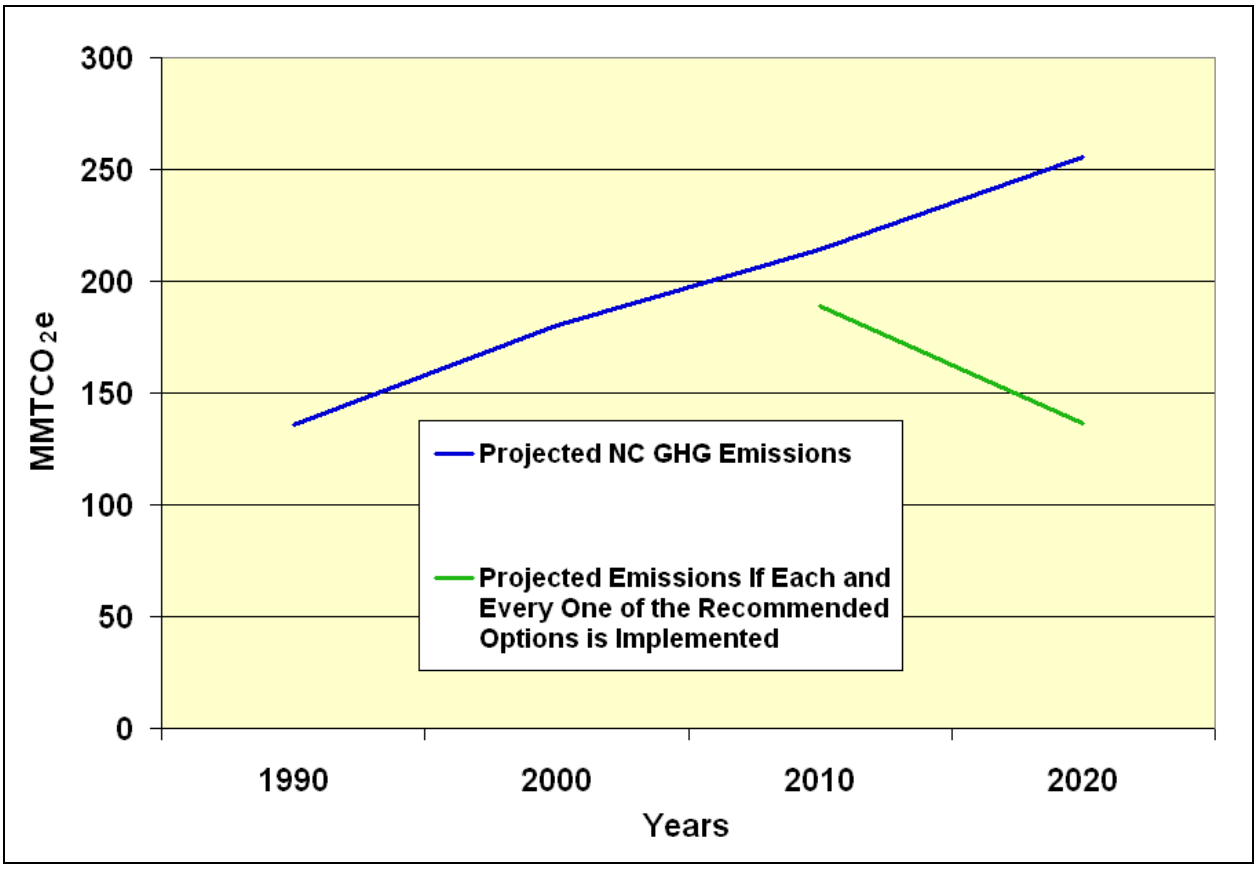


Table 1-1. Annual Emissions: Reference Case Projections, and Impact of CAPAG Recommendations (Consumption-Basis, Gross Emissions)

Annual Emissions ($MMTCO_2e$)	1990	2000	2010	2020
Reference Case Projections	135.6	180.1	214.5	255.6
GHG Reductions From CAPAG Recommendations			25.5	119.0
Annual Emissions With CAPAG Recommendations			189.0	136.6

The CAPAG's recommendations tabulated in the Executive Summary, along with a listing of the estimated reductions for each. Chapters 3 through 7 and the Appendices provide detailed descriptions and analysis of GHG reductions, costs, additional impacts, feasibility, etc. for individual options developed by the five TWGs/sectors:

- Residential, Commercial, Industrial (RCI)
- Energy Supply (ES)
- Transportation and Land Use (TLU)
- Agriculture and Forestry (AF)
- Cross-Cutting Issues (CC)

Table 1-2. Summary by Sector of Estimated Impacts of Implementing All of the CAPAG Recommendations

Sector	GHG Reductions ($MMtCO_2e$)			Net Direct Cost (Million $)	Cost-Effective-ness ($\$/tCO_2e$)
	2010	2020	Total 2007-2020	2007–2020 (NPV)	
Residential, Commercial and Industrial (RCI, non-electricity options only)	0.1	1.5	7.9	–987	N/A
Energy Supply (ES, including RCI options with impacts on electricity consumption, and adjusted for RCI and ES electricity options that overlap)	6.5	62.7	375	–5.9	–0.016
Transportation and Land Use	11.1	25.5	232	–4,350	–19
Agriculture, Forestry and Waste Management	7.8	29.3	213	270	1.27
Cross-Cutting Issues	*Non-quantified, enabling options*				
TOTAL (includes all adjustments for overlaps and recent actions)*	**25.5**	**119**	**828**	**–5,073**	**N/A**

*Notes: NPV=Net Present Value. Negative values in the Net Direct Cost and the Cost-Effectiveness columns represent, as discussed above, net *cost savings* associated with the options. Within each sector, values have been adjusted to eliminate double counting for options or elements of options that overlap. In addition, values associated with options or elements of options within a sector that overlap with options or elements of options in another sector have been adjusted to eliminate double counting.

N/A = Not available; for RCI non-electricity options, an overall cost-effectiveness value is not provided because dividing the net non-electric cost savings (mostly due to natural gas energy efficiency) by the net non-electric emission reductions (which factors in both additional fuel for combined heat and power (CHP) and gas savings from energy efficiency) yields results that can be misleading.

For the ES sector, emission reductions and costs associated with ES-2b, ES-4a, and ES 6a (see Table 1-3) were used to estimate the cumulative impacts shown in Table 1-2. Note that the row in Table 1-2 for the RCI sectors includes only that portion of RCI emissions reductions and net costs (in this case, cost savings) that are from RCI options (or elements of options) that affect fuels that are combusted for purposes other than to generate electricity. RCI emissions reductions and net costs that affect electricity use or generation are included in the ES row in Table 1-2, because the emissions reductions and costs of electricity-sector options are dependent on the electrical load served, which is affected by RCI electricity savings. As a result, the net cost savings reported in the ES row in Table 1-2, -$5.9 million, is actually the sum of a large estimated net savings from RCI options and a large estimated net cost from ES options.

Table 1-3. Summary of CAPAG's 56 Mitigation Option Recommendations by Sector

	Mitigation Option Name	GHG Reductions ($MMtCO_2e$)			Net Direct Cost (Million $)	Cost-Effective-ness ($/$tCO_2e$)	Level of Support
		2010	2020	Total 2007–2020	2007–2020 (NPV)		
	Residential, Commercial, and Industrial (RCI)						
RCI–1	Demand Side Management Programs for the RCI Sectors - Recommended Case: "Top-Ten States" EE Investment	1.9	11.6	77.1	–1,895	–25	UC
RCI–2	Expand Energy Efficiency Funds	1.5	8.0	54.8	–1,346	–25	UC
RCI–3	Energy Efficiency Requirements for Government Buildings	0.0	1.1	6.4	–88	–14	UC
RCI–4	Market Transformation and Technology Development Programs	0.0	2.0	10.5	–339	–32	UC
RCI–5	Improved Appliance and Equipment Efficiency Standards	0.0	1.0	5.3	–336	–63	UC
RCI–6	Building Energy Codes	0.5	3.5	23.1	–400	–17	UC
RCI–7	"Beyond Code" Building Design Incentives and Targets, Incorporating Local Building Materials and Advanced Construction	0.7	5.2	34.2	–494	–14	UC
RCI–8	Education (Consumer, Primary/Secondary, Post-Secondary/ Specialist, College and University Programs)	Not quantified					UC
RCI–9	Green Power Purchasing (required for state facilities) and Bulk Purchasing Programs for Energy Efficiency or Other Equipment	0.1	0.5	3.5	11	3	UC
RCI–10	Distributed Renewable and Clean Fossil Fuel Power Generation	1.2	4.6	33.5	392	12	UC
RCI–11	Residential, Commercial, and Industrial Energy and Emissions Technical Assistance and Recommended Measure Implementation	0.5	2.1	14.9	–494	–33	UC
	Sector Total After Adjusting for Overlaps	**5.3**	**33.0**	**218.7**	**–3,994**	**–18**	
	Reductions From Recent Actions**	**0.5**	**1.2**	**10.1**			
RCI–1	Demand Side Management Programs for the Residential, Commercial and Industrial Sectors	0.3	0.7	6.2			
RCI–2	Expand Energy Efficiency Funds	0.2	0.4	3.6			
RCI–6	Building Energy Codes	0.0	0.0	0.0			
RCI–9	Green Power Purchasing (required for state facilities) and Bulk Purchasing Programs for Energy Efficiency or Other Equipment	0.0	0.0	0.3			
	Sector Total Plus Recent Actions	**5.8**	**34.2**	**228.8**			

	Mitigation Option Name	GHG Reductions ($MMtCO_2e$)			Net Direct Cost (Million $)	Cost-Effective-ness ($/$tCO_2e$)	Level of Support
		2010	2020	Total 2007–2020	2007–2020 (NPV)		
	Energy Supply (ES)						
ES-1	Renewable Energy Incentives	0.01	0.04	0.33	15	45.1	UC
ES-2	Environmental Portfolio Standard						
ES-2a	Original Analysis	6.94	44.3	288.7	1,634	5.7	UC
ES-2b	20% Combined Target	5.90	23.4	166.2	409.80	2.5	UC
ES-2c	Load Growth Offset Target	5.53	22.3	160.3	393.95	2.5	UC
ES-3	Removing Barriers to CHP and Clean DG	0.69	2.8	20.1	127.98	6.4	UC
ES-4	CO_2 Tax and/or Cap-and-Trade						
ES-4a	Electric Sector Only	0.84	3.3	20.4	119	5.8	SMJ
ES-4b	Economy-wide	1.84	7.1	47.7	284	6.0	SMJ
ES-5	Legislative Changes to Address Environmental and Other factors	Not quantified					UC
ES-6	Incentives for Advanced Coal						
ES-6a	Replacement of New 800 MW Pulverized Coal Plant	0.00	3.9	31.0	949	30.6	UC
ES-6b	Replacement of Existing 800 MW Pulverized Coal Plant	0.00	5.4	42.9	2,061	48.1	UC
ES-7	Public Benefit Charge	0.8	3.4	24.4	329	13.5	SMJ
ES-8	Waste to Energy	0.0	0.0	0.02	–0.7	–36.8	UC
ES-9	Incentives for CHP and Clean DG	Combined with ES-3					UC
ES-10	NC GreenPower Renewable Resources Program	0.01	0.2	0.95	35	37.0	UC
	Sector Total After Adjusting for Overlaps*	**6.5**	**62.7**	**375**	**–5.9**	**–0.016**	
	Reductions From Recent Actions (None)	**0**	**0**	**0**	**0**	**0**	
	Sector Total Plus Recent Actions*	**6.5**	**62.7**	**375**	**–5.9**	**–0.016**	

	Mitigation Option Name	GHG Reductions ($MMtCO_2e$)			Net Direct Cost (Million $)	Cost-Effective-ness ($/$tCO_2e$)	Level of Support
		2010	2020	Total 2007–2020	2007–2020 (NPV)		
	Transportation and Land Use (TLU)						
TLU-1a	Land Development Planning	2.6	8.0	58.2	Net savings		SMJ
TLU-1b	Multi-Modal Transportation and Promotion (formerly TLU-2)	3.7	5.8	52.4	–1,300	–25	UC
TLU-3a	Surcharges to Raise Revenue	1.2	2.2	15.7	–1,800	–117	SMJ
TLU-3b	Rebates/ Feebates to Change Fleet Mix	0	< 0.5	2.8	Not quantified	–40 to +10	SMJ
TLU-4	Truckstop Electrification	Included in TLU–8			Net savings		UC
TLU-5	Tailpipe GHG Standards	0	8.1	44.5	–1,150	–38	SMJ
TLU-6	Biofuels Bundle	1.9	4.5	35.4	Not quantified		UC
TLU-7	Procure Efficient Fleets	Included in TLU–6					UC
TLU-8	Idle Reduction/Elimination Policies	0.1	0.2	2.2	–6	–4	UC
TLU-9	Diesel Retrofits	0.3	2.2	13.5	Not quantified		UC
TLU-11	Pay-As-You Drive Insurance	2.3	5.3	42.0	Expected net savings		SMJ
TLU-12	Advanced Technology Incentives	Not quantified					UC
TLU-13	Buses – Clean Fuels	Included in TLU–6					UC
	Sector Total After Adjusting For Overlaps	**11.1**	**25.5**	**232.3**	**–4,350**	**–19**	
	Reductions From Recent Actions (None)	**0**	**0**	**0**	**0**	**0**	
	Sector Total Plus Recent Actions	**11.1**	**25.5**	**232.3**	**–4,350**	**–19**	

	Mitigation Option Name	GHG Reductions ($MMtCO_2e$)			Net Direct Cost (Million $)	Cost-Effective-ness ($/$tCO_2e$)	Level of Support
		2010	2020	Total 2007–2020	2007–2020 (NPV)		
	Agriculture, Forestry, and Waste (AFW)						
AFW-1	Manure Digesters & Energy Utilization	0.2	0.9	6.4	199	32	UC
AFW-2	Biodiesel Production (incentives for feedstocks and production plants)	0.2	0.8	5.1	286	56	UC
AFW-3	Soil Carbon Management (including organic prod. methods incentives)	0.2	0.2	3.0	–16	–5	UC
AFW-4a	Preservation of Working Land–Agricultural Land	0.2	0.3	2.6	290	114	UC
AFW-4b	Preservation of Working Land–Forest Land (formerly AFW-7)	1.7	4.3	36	112	3	UC
AFW-5	Agricultural Biomass Feedstocks for Electricity or Steam Production	0.009	0.02	0.2	10	54	UC
AFW-6	Policies to Promote Ethanol Production	0.9	6.9	38	200	5	UC
AFW-8	Afforestation and/or Restoration of Nonforested Lands	0.2	2.4	15	128	9	UC
AFW-9&10	Expanded Use of Forest Biomass and Better Forest Management	1.5	5.9	48	–639	–13	UC
AFW-11	Landfill Methane and Biogas Energy Programs	1.1	2.9	20	23	1	UC
AFW-12	Increased Recycling Infrastructure and Collection	0.2	0.5	4.1	52	13	UC
AFW-13	Urban Forestry Measures	1.4	4.3	34	–376	–11	UC
	Sector Total After Adjusting For Overlaps	**7.9**	**29**	**213**	**270**	**1**	
	REDUCTIONS FROM RECENT ACTIONS (None)	**0**	**0**	**0**	**0**	**0**	
	Sector Total Plus Recent Actions	**7.9**	**29**	**213**	**270**	**1**	

	Mitigation Option Name	GHG Reductions ($MMtCO_2e$)			Net Direct Cost (Million $)	Cost-Effective-ness ($/$tCO_2e$)	Level of Support
		2010	2020	Total 2007–2020	2007–2020 (NPV)		
	Cross-Cutting Issues (CC)						
CC-1	GHG Inventories and Forecasts	*Not quantified*					UC
CC-2	GHG Reporting	*Not quantified*					UC
CC-3	GHG Registry	*Not quantified*					UC
CC-4	Public Education and Outreach	*Not quantified*					UC
CC-5	Adaptation	*Not quantified*					UC
CC-6	Options for Goals or Targets (for CAPAG in support of LCGCC)	*Not quantified*					UC

For “Level of Support” column: UC = unanimous consent (all CAPAG members attending meeting agree), SMJ = supermajority (80% or more of the CAPAG members attending meeting agree).

NPV=Net Present Value. Negative values in the Net Direct Cost and the Cost-Effectiveness columns represent, as discussed above, net *cost savings* associated with the options.

Some options were renumbered (i.e., AFW-7 to AFW-4b; TLU-2 to TLU-1b) or combined (e.g., AFW-9&-10), and others were divided into sections a, b, c to yield a total of 56 options supported by CAPAG.

* For ES-2, ES-4, and ES-6, emission reductions and costs associated with ES-2b, ES-4a, and ES-6a were used to estimate the cumulative impacts shown in Tables 1-2 and 1-3.

** “Recent actions” represent initiatives undertaken in North Carolina that reduce GHG emissions that were implemented shortly before or during the CAPAG process. The emission reductions associated with recent actions are not accounted for in the GHG emissions inventory and reference case projections. Emissions reductions associated with these recent actions were therefore estimated separately, and are counted toward overall statewide reductions along with reductions from the mitigation options recommended by the CAPAG.

Perspectives on Mitigation Option Recommendations

There can be a large imprecision in the GHG reductions associated with various options. Figure 1-3 presents the estimated tons of reductions for each mitigation option recommendation for which estimates were available, expressed as a cumulative figure for the period 2007–2020.

In addition to the imprecision in GHG reductions achieved by each option, there are also uncertainties in the exact cost (or cost savings) per ton of reduction achieved. Figure 1-4 presents the estimated dollars per ton cost (or cost savings, depicted as a negative number) for each recommended mitigation option, for which cost estimates were available. This measure is calculated by dividing the net present value of the cost of the option by the cumulative GHG reductions, all for the period 2007–2020.

In some cases, there is a wide variation in the cost effectiveness of mitigation options depending on the assumptions used in the analysis. As an example, option TLU-5 (Tailpipe GHG Standards) recommends that North Carolina adopt California GHG emissions standards for light-duty vehicles to reduce GHG emissions (also known as the Pavley standards). California standards require GHG emissions reductions of about 30% from new vehicles, phased in from 2009 to 2016, through a variety of means. The California Air Resources Board (CARB) estimated that the cost of compliance in a new vehicle in model year 2016 would be approximately $1,000. To determine the net impact on consumers, CARB calculated the increase in monthly loan payments versus the savings from reduced fuel consumption. Their net resulting estimate is that consumers would achieve a net savings, starting at the time of purchase, of approximately $3.50 to $7.00 / month.

In contrast, automobile manufacturers estimate that the California standards would cost around $3,000 per vehicle, and calculated that savings on fuel would offset less than half of that cost for consumers. A review of the literature and assumptions used to derive the different estimates gives a range of cost-effectiveness values of –$38 to –$117 per ton of CO_2e reduced. That is, for each ton reduced, between $38 and $117 would be saved. More than ten other states have adopted the California standards and, among other factors that support the use of a savings estimate toward the higher end of the range, manufacturers should realize economies-of-scale that would lower manufacturing costs as additional states adopt and implement the standards. Although we believe that savings are likely to be higher than the –$38 per ton end of the range,

we use a cost-effectiveness of –$38 per ton of CO_2e reduced in our calculations in an effort to be conservative.

Note that this option cannot be implemented until any pending law suits are settled and the US Environmental Protection Agency issues a waiver under the Clean Air Act authorizing California to implement the standards. This may take some months.

Figure 1-3. CAPAG Mitigation Option Recommendations Ranked by Cumulative GHG Reductions, 2007–2020

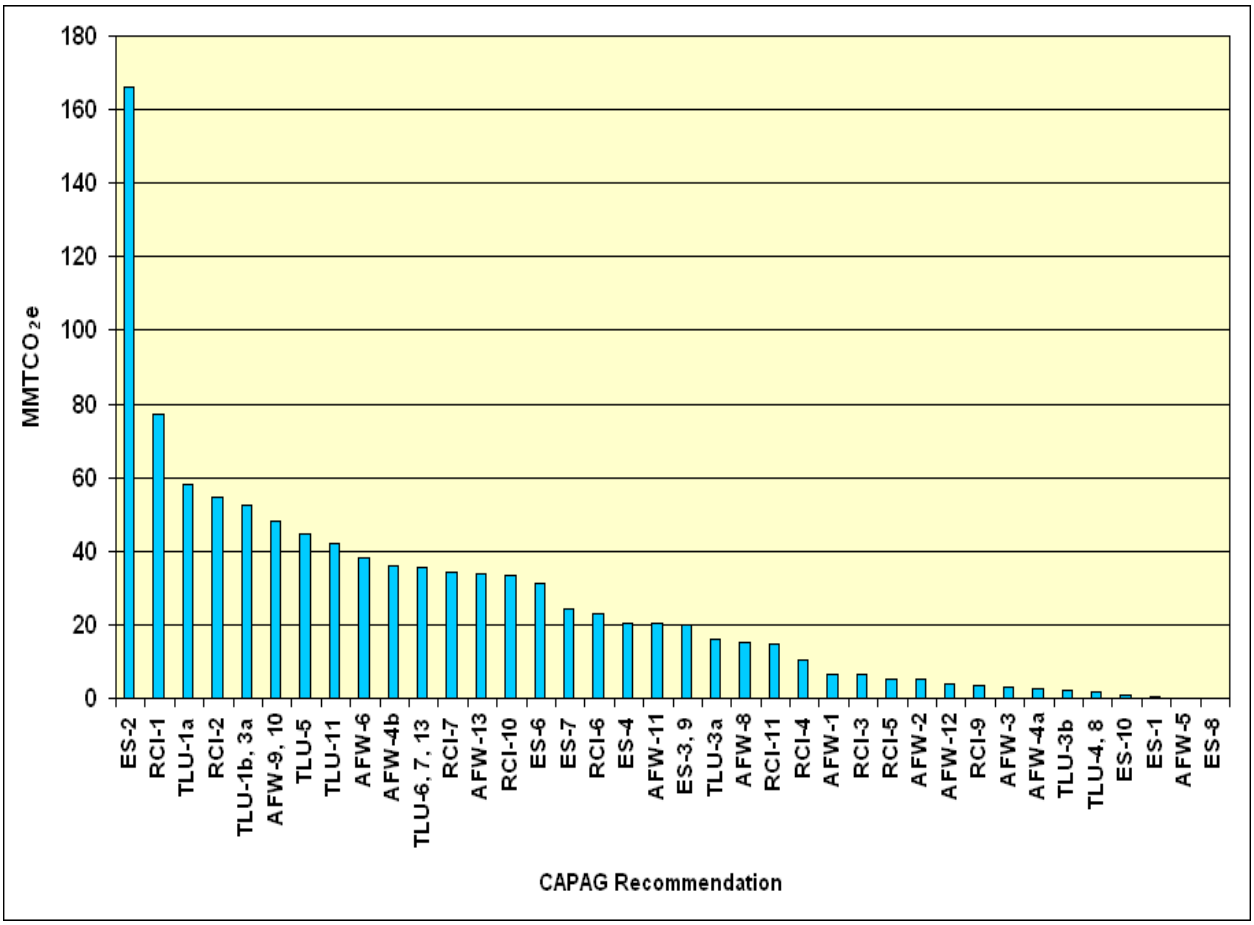
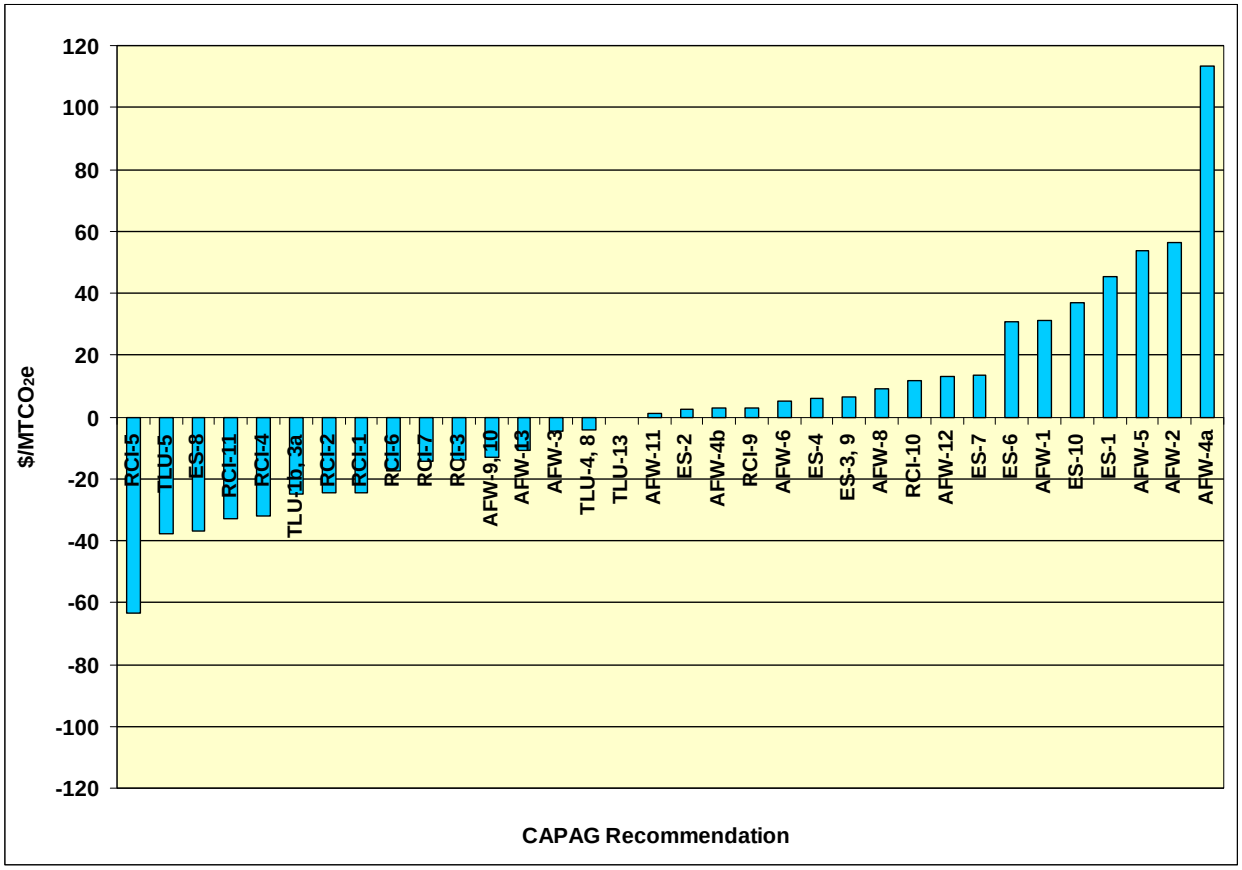


Figure 1-4. CAPAG Mitigation Option Recommendations Ranked by Dollars per Ton



Note: Negative values represent net cost savings and positive values represent net costs associated with the mitigation options.

Secondary Economic Impact Analysis of Mitigation Options

In July 2007, CCS engaged the Appalachian State University (ASU) Energy Center to conduct further analysis of the potential economic and jobs impact of the CAPAG's recommended mitigation options. Resource limitations prevented analysis of all options so, in consultation with DAQ/ DENR, the ASU Energy Center prioritized thirty options for analysis. Together these options account for more than 90% of the GHG emissions reductions associated with the recommended mitigation options. The thirty options were bundled into twenty-three scenarios with similar options grouped together for analysis. This analysis was not part of the materials that were available and discussed or reviewed by the CAPAG directly but is believed consistent with their work and recommendations. The details of this study are included separately as a stand-alone report.[10]

For the study, the ASU Energy Center utilized the NC Energy Scenario Economic Impact Model (NC ESEIM). Originally developed in 2005 for the North Carolina Energy Policy Council, the

[10] A complete copy of the ASU Energy Center report entitled "Secondary Economic Impact Analysis of GHG Mitigation Options for North Carolina" is available at http://www.ncclimatechange.us or http://daq.state.nc.us/monitor/eminv/gcc.

peer-reviewed model assesses the impacts of various energy policies on the North Carolina economy, measured in terms of employment, employee and proprietor compensation (income), and the incomes earned by labor and capital (gross state product).

At the core of the NC ESEIM is an input-output economic impact model that estimates how a given change in public policy might result in positive or negative impacts to the economy. Input-output analysis conceives of the economy as a set of interrelated sectors where the consumption of finished goods and services, or final demand, catalyzes a chain reaction of production. As final demand for goods and services change, the upstream sectors in the economy respond accordingly, creating a ripple or multiplier effect. The economic multipliers in the NC ESEIM are derived from data published by the Minnesota IMPLAN Group.[11]

This approach is distinguishable from the approach undertaken by the CAPAG. The CAPAG sought to quantify the direct costs and cost savings borne by those entities implementing an option to mitigate GHG emissions. The quantified costs were subtracted from the quantified cost savings to produce a "net direct cost." Building on the work of the CAPAG, the ASU Energy Center sought to measure the full multiplier effect of both positive and negative changes in final demand resulting from a given option. Moreover, the secondary analysis considers the relative effect of an option on all of the affected sectors of the state's economy.[12] Therefore, the ASU Energy Center report should be considered a complement to the CAPAG report that seeks to identify the likely ancillary effects of implementing a given option.

While more sophisticated econometric models exist, input-output analysis is typically a reasonable approximation of the economic impacts associated with the type of modest policy changes considered by the CAPAG. Moreover, numerous national, regional, and state-level studies, including reports for Florida, Maryland, and Texas, utilize a similar approach in estimating the potential economic impacts of changes in energy policy.[13]

The NC ESEIM, as well as its application in the Secondary Economic Impact Analysis, has undergone extensive peer-review. An initial review of the model was performed by Adam Rose, Ph.D., Economist and Research Professor at the University of Southern California (Rose and Wei 2005). Dr. Rose also coordinated an anonymous peer review of the Secondary Economic Impact Analysis during the summer of 2008. Based on these comments the Energy Center has made a number of refinements to the underlying methodology so as to fully and properly account for the potential implications of the options analyzed.[14]

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[11] Minnesota IMPLAN Group, Inc. (2005). North Carolina State Data Package, 2004.Stillwater, MN, Minnesota IMPLAN Group, Inc. The Minnesota IMPLAN Group (www.implan.com) is the developer of IMPLAN Professional, a computer software application for conducting input-output economic analysis in use by more than 1,000 public and private institutions.

[12] For a more detailed overview of the analytical approach used by the NC ESEIM please refer to Chapter 1 of the ASU Energy Center Report.

[13] See Laitner, J.A. 2008. "Positive Returns: State Energy Efficiency Analyses Can Inform U.S. Energy Policy Assessments." American Council for and Energy Efficient Economy, at http://www.aceee.org/.

[14] For a complete discussion of the methodological refinements made as a result the peer review process please refer to Appendix C of the ASU Energy Center Report.

On the whole, implementation of the modeled mitigation option bundles would result in a mildly positive economic impact on North Carolina's economy. By 2020, the mitigation options analyzed would result in the creation of more than 15,000 jobs, $565 million in employee and proprietor income, and $302 million in gross state product. For the study period, 2007–2020, the mitigation options analyzed would generate more than $2.2 billion net present value (NPV) in net additional employee and proprietor income and more than $1.2 million (NPV) in net gross state product (see Table 1-4).[15] The base year for the NC ESEIM is 2004; therefore all results are reported in 2004 dollars.

Table 1-4. Economic Impact Analysis Summary Results for All Options Analyzed in Key Years

	Net Annual Employment (FTE)			Net Income ($2004, million)				Total Value Added ($2004, million)			
	2010	2015	2020	2010	2015	2020	2007–2020 (NPV)	2010	2015	2020	2007–2020 (NPV)
Energy Supply Options	–409	–384	1,744	–41	–53	26	–297	–99	–152	–118	–1,046
Residential, Commercial, and Industrial Options	3,518	6,961	9,110	136	271	364	1,942	114	125	42	937
Agriculture, Forestry, and Waste Management Options	1,202	1,960	3,318	39	75	183	649	78	145	331	1,267
Transportation and Land Use Options	783	432	871	–1	–19	–8	–91	24	7	48	128
All Options Analyzed	**5,094**	**8,970**	**15,042**	**134**	**274**	**565**	**2,203**	**116**	**126**	**302**	**1,287**

Note: Negative values identify loss of jobs, income, or value added. FTE = full-time equivalent; NPV = net present value.

Table 1-5 presents summary results for the ES mitigation options analyzed. By 2020, these options would result in the creation of more than 1,700 jobs, $26 million in employee and proprietor income, but a decrease in $118 million in gross state product. Over the study period, 2007–2020, the options would decrease employee and proprietor income by $297 million (NPV) and net gross state product by $1.046 billion (NPV).The base year for the NCESEIM is 2004; therefore all results are reported in 2004 dollars.

The negative effects of the option are driven primarily by the technology and fuel price assumptions of the CAPAG, which result in a "negative payback" where commercial and industrial end-users spend more to install and operate CHP systems than a business as usual case. As a result, firms in these sectors reduce their final demand for endogenous goods and services, the effect of which is amplified throughout the economy, causing the negative effects. Moreover,

[15] Net present value (NPV) is calculated assuming a discount rate of 5%.

in order to remain consistent with the final integration of all option preformed by the CAPAG, the efficiency components of ES-2 are assumed to obtained by the demand side options of the RCI sectors.

Table 1-5. Summary Results for Energy Supply (ES) Options Analyzed

	Net Annual Employment (FTE)			Net Income ($2004, million)				Total Value Added ($2004, million)			
Energy Supply Options	**2010**	**2015**	**2020**	**2010**	**2015**	**2020**	**2007–2020 (NPV)**	**2010**	**2015**	**2020**	**2007–2020 (NPV)**
ES-1 & -2 and AFW-5 (PTC, REPS, Biomass)	–11	330	2,148	–0	10	90	116	–0	5	77	54
ES-3 & -9 (CHP)	–541	–271	34	–48	–48	–48	–361	–112	–146	–183	–1,094
ES-6a (IGCC)	98	–100	–96	4	–4	–4	–6	6	–5	–6	–6
ES-6b (IGCC)	45	–341	–333	3	–11	–12	–78	6	–5	–7	–3
ES-8 (Municipal Biogas)	0	–2	–10	0	–0.1	–0.5	–0.9	–0	–0.2	–0.7	–1.5
All ES Options	–409	–384	1,744	–41	–53	26	–297	–99	–152	–118	–1,046

Note: Negative values identify loss of jobs, income, or value added. FTE = full-time equivalent; NPV = net present value.

Table 1-6 presents summary results for the RCI mitigation options analyzed. By 2020, these options would result in the net creation of more than 9,100 jobs, $364 million in additional employee and proprietor income, and $42 million in net gross state product. Over the study period, 2007–2020, the options would generate $1.9 billion (NPV) in additional employee and proprietor income and $937 million (NPV) in gross state product. The economic impacts associated with these options are driven primarily by energy bill savings resulting from energy efficiency measures.

Table 1-6. Summary Results for Residential, Commercial & Industrial (RCI) Options Analyzed

	Net Annual Employment (FTE)			Net Income ($2004, million)				Total Value Added ($2004, million)			
Residential, Commercial & Industrial Options	**2010**	**2015**	**2020**	**2010**	**2015**	**2020**	**2007 –2020 (NPV)**	**2010**	**2015**	**2020**	**2007–2020 (NPV)**
RCI-1, -2 & -11 (Efficiency Funding & Energy Audits)	1,309	3,121	4,575	45	105	160	789	18	–4	–55	36
RCI-4 & -5 (Market Transformation & Appliance Standards)	-	430	771	-	15	26	87	-	1	–11	–9
RCI-6 (Energy Codes)	1,964	2,076	2,163	83	86	90	623	96	77	57	571
RCI-7 & -3 (High Performance Building)	126	1,239	1,372	3	61	76	388	–5	46	32	273
RCI-9 (Bulk Purchasing)	105	99	12	4	4	–1	33	5	3	–5	28
RCI-10 (Residential Solar Hot Water Only)	13	–4	218	1	0	13	21	0	1	24	37
All RCI Options	3,518	6,961	9,110	136	271	364	1,942	114	125	42	937

Note: Negative values identify loss of jobs, income, or value added. FTE = full-time equivalent; NPV = net present value.

Table 1-7 presents summary results for the AFW options analyzed. By 2020, these options would result in the net creation of more than 3,300 jobs, $183 million in additional employee and proprietor income, and $331 million in gross state product. Over the study period, 2007–2020, the options would generate nearly $649 million (NPV) in additional employee and proprietor income and $1.2 billion (NPV) in gross state product. The positive economic impacts associated with these options are driven primarily by capital investments to build manufacturing capacity to meet the biofuels production goals articulated in the mitigation options.

Table 1-7. Summary Results for Agriculture, Forestry, and Waste Management (AFW) Options

	Net Annual Employment (FTE)			Net Income ($2004, million)				Total Value Added ($2004, million)			
Agriculture, Forestry, and Waste Management Options	**2010**	**2015**	**2020**	**2010**	**2015**	**2020**	**2007–2020 (NPV)**	**2010**	**2015**	**2020**	**2007–2020 (NPV)**
AFW-1 (Manure Digesters)	51	48	53	2	2	2	19	3	2	2	24
AFW-2 (Biodiesel)	51	48	53	–6	–12	10	–72	–7	–15	17	–85
AFW-4a & -4b (Easements)	2	–4	3	–.2	–1	–1	–4	1	2	4	18
AFW-6 (Cellulosic Ethanol)	547	1,399	2,781	23	74	163	547	43	135	298	1,016
AFW-8 (Afforestation)	–13	–45	66	–1	–2	4	–9	–1	–3	8	–8
AFW-9 & -10 (Forest Management)	–9	–33	–48	–2	–6	–9	–41	–.1	–.3	–.4	–2
AFW-11 (Landfill Gas)	–6	–24	–5	–.1	–1	0.4	–2	1	–.3	2	4
AFW-12 (Recycling)	1	2	6	.1	.1	.3	2	.3	.3	1	3
AFW-13 (Urban Forestry)	566	524	475	22	19	17	106	37	22	8	115
All AFW Options	1,202	1,960	3,318	39	75	183	649	78	145	331	1,267

Note: Negative values identify loss of jobs, income, or value added. FTE = full-time equivalent; NPV = net present value.

Table 1-8 presents summary results for the TLU mitigation options analyzed. By 2020, these options would result in the creation of more than 870 net jobs and $48 million in net gross state product but the loss of $8 million in employee and proprietor income. Over the study period, 2007–2020, the options would generate $128 million (NPV) in gross state product but the loss of $91 million (NPV) in employee and proprietor income. The bulk of the positive economic impacts associated with these options are driven by consumer re-spending of reduced vehicle operating costs.

The negative impacts associated with TLU-5 are largely the result of the relative effect of reduced vehicle operating costs versus the displacement of retail gasoline sales. While TLU-5 results in a net savings to vehicle owners, the positive multiplier effect of these savings do not outweigh the constrictive multiplier effect of displaced retail gasoline sales. However, it should be noted that the modeling assumptions of this option are intentionally conservative. For example, it assumes as the U.S. Energy Information Administration's 2007 regional retail fuel price forecast for gasoline, which averages $2.21 per gallon over the study period and is considerably lower than the current market prices. Variability in the baseline fuel price

assumption is considered and discussed in a set of sensitivity analyses in Chapter 6 of the ASU Report. These sensitivities suggest that if energy prices remain at, or near, their recent highs then vehicle greenhouse emissions standards would result in substantial positive economic impacts.

Table 1-8. Summary Results for Transportation and Land Use (TLU) Options Analyzed

	Net Annual Employment (FTE)			Net Income ($2004, million)				Total Value Added ($2004, million)			
Transportation and Land Use Options	**2010**	**2015**	**2020**	**2010**	**2015**	**2020**	**2007–2020 (NPV)**	**2010**	**2015**	**2020**	**2007–2020 (NPV)**
TLU-1b (Shift to Transit Spending)	98	127	252	–29	–31	–27	–213	–23	–26	–19	–173
TLU-3a (Registration Surcharge for Transit Spending)	718	646	632	30	28	28	205	49	45	46	332
TLU-5 (CO_2 Tailpipe Standard)	–32	–341	–14	–1	–17	–9	–83	–2	–12	21	–31
All TLU Options	783	432	871	–1	–19	–8	–91	24	7	48	128

Note: Negative values identify loss of jobs, income, or value added. FTE = full-time equivalent; NPV = net present value.

Potential Investment Costs Associated with Mitigation Options

At its October 16, 2007 meeting, the CAPAG requested a summary of the potential annual upfront public and private investments associated with the mitigation options. These results are summarized in Table 1-9. The potential annual investment costs associated with the options are based on the methods used to estimate the costs or cost savings of each option analyzed during the CAPAG process, and supplemental research conducted by the Appalachian State University (ASU) Energy Center. [16]

While implementation of some of the mitigation options may require significant upfront investments of public and/or private resources, these investments, in many cases, also result in significant savings over time. Moreover, many of the mitigation options result in ongoing savings beyond the period included in the CAPAG and ASU Energy Center analyses. Finally, almost all of these initial investment costs will be financed over time reducing the actual annual costs borne by the public and private sectors.

Consider for example TLU-5 (Tailpipe GHG Standards). As noted above, this mitigation option would require automakers to install additional pollution control technologies increasing the purchase price of a new vehicle and monthly car payments. However, these same pollution control technologies will increase fuel economy and reduce the vehicle operating expenses, which tend to offset the increased purchase price.

[16] Documentation of the methods used to develop estimates of the upfront investment costs is provided in the ASU Energy Center's report "Secondary Economic Impact Analysis of GHG Mitigation Options for North Carolina," at http://www.ncclimatechange.us or http://daq.state.nc.us/monitor/eminv/gcc.

Table 1-9. Projected Potential Upfront Investment Costs of Mitigation Options (Million in 2005 Dollars)

	2010	2015	2020	2007–2020 (NPV)
Energy Supply Options				
ES-1 (Renewable Energy Incentives)				
Private investment	10	61	124	414
Public investment	1	2	2	13
Total investment	10	63	127	426
ES-2 (Environmental Portfolio Standard, SB3 Analysis)				
Private investment	-	676	911	4,310
Total investment	-	676	911	4,310
ES-3 & -9 (CHP)				
Private investment	238	396	570	3,082
Total investment	238	396	570	3,082
ES-6a (IGCC versus new pulverized coal)				
Private investment	47	9	9	195
Total investment	47	9	9	195
ES-6b (IGCC displacing existing pulverized coal)				
Private investment	318	69	69	1,353
Total investment	318	69	69	1,353
ES-8 (Municipal Biogas)				
Public investment	0.2	1	3	9
Total investment	-	1	3	9
All ES Policies				
Private investment	**613**	**1,211**	**1,686**	**9,037**
Public investment	**1**	**3**	**5**	**21**
Total investment	**614**	**1,214**	**1,692**	**9,058**
Residential, Commercial, and Industrial Options				
RCI-1 (Efficiency Funding)				
Private investment	208	329	368	2,527
Total investment	208	329	368	2,527
RCI-2 (1% PBF)				
Private investment	146	154	173	1,242
Total investment	146	154	173	1,242
RCI-11 (Energy Audits)				
Private investment	9	10	10	84
Total investment	9	10	10	84
RCI-4 (Market Transformation)				
Private investment	-	8	19	53
Total investment	-	8	19	53
RCI-5 (Appliance Standards)				
Private investment	-	25	25	141
Total investment	-	25	25	141

	2010	2015	2020	2007–2020 (NPV)
RCI-6 (Energy Codes)				
Private investment	225	227	231	1,640
Total investment	225	227	231	1,640
RCI-3 (Energy Efficient Government Buildings)				
Public investment	-	63	71	397
Total investment	-	63	71	397
RCI-7 (High-Performance Buildings)				
Private investment	56	93	93	671
Total investment	56	93	93	671
RCI-9 (Bulk Purchasing)				
Private investment	59	59	-	470
Public investment	2	4	5	26
Total investment	61	63	5	496
RCI-10 (Residential Solar Hot Water Heating Only)				
Private investment	37	41	44	351
Total investment	37	41	44	351
All RCI Policies				
Private investment	**740**	**947**	**964**	**7,188**
Public investment	**1.686**	**66**	**76**	**423**
Total investment	**742**	**1,014**	**1,040**	**7,611**
Agriculture, Forestry, and Waste Management Options				
AFW-1 (Manure Digesters)				
Private investment	19	28	39	238
Total investment	19	28	39	238
AFW-2 (Biodiesel)				
Private investment	45	88	93	414
Public investment	24	49	15	273
Total investment	69	138	107	686
AFW-4a (Farmland Easements)				
Public investment	21	31	51	263
Total investment	21	31	51	263
AFW-4b (Forestland Easements)				
Public investment	8	14	20	107
Total investment	8	14	20	107
AFW-5 (Biomass Subsidy)				
Public investment	3	-	-	10
Total investment	3	-	-	10
AFW-6 (Cellulosic Ethanol)				
Private investment	188	339	742	3,008
Public investment	25	-	-	190
Total investment	213	339	742	3,198
AFW-8 (Afforestation)				
Public investment	3	15	15	98
Total investment	3	15	15	98

	2010	2015	2020	2007–2020 (NPV)
AFW-9 & -10 (Forest Management)				
Public investment	16	54	78	358
Total investment	16	54	78	358
AFW-11 (Landfill Gas)				
Private investment	12	12	15	112
Total investment	12	12	15	112
AFW-12 (Recycling)				
Private investment	6	10	15	79
Total investment	6	10	15	79
AFW-13 (Urban Forestry)				
Private investment	96	84	76	896
Total investment	96	84	76	896
All AFW Policies				
Private investment	**382**	**616**	**1,057**	**5,105**
Public investment	**81**	**167**	**255**	**1,353**
Total investment	**463**	**784**	**1,312**	**6,459**
Transportation and Land Use Options				
TLU-1b (Shift to Transit Spending)				
Public investment	347	347	347	2,487
Total investment	347	347	347	2,487
TLU-3a (Registration Surcharge for Transit $)				
Public investment	33	33	33	239
Total investment	33	33	33	239
TLU-5 (CO_2 Tailpipe Standard)				
Private investment	26	401	553	2,341
Total investment	26	401	553	2,341
All TLU Options				
Private investment	**26**	**401**	**553**	**2,702**
Public investment	**380**	**380**	**380**	**3,156**
Total investment	**406**	**781**	**933**	**5,858**

NPV = net present value (calculated assuming a discount rate of 5%); SB = Senate Bill; CHP = combined heat and power; IGCC = integrated gasification combined cycle; PBF = Public Benefits Fund; CO_2 = carbon dioxide.

Chapter 2
Inventory and Projections of GHG Emissions

Introduction

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

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

The *Inventory and Projections* covers the six types of gases included in the U.S. Greenhouse Gas Inventory: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF_6). Emissions of these GHGs are presented using a common metric, CO_2 equivalence (CO_2e), which indicates the relative contribution of each gas, per unit mass, to global average radiative forcing on a global warming potential– (GWP–) weighted basis.

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

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

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

[3] The last year of available historical data varies by sector, ranging from 2000 to 2004.

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

North Carolina Greenhouse Gas Emissions: Sources and Trends

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

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

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

(Million Metric tons CO_2e)	1990	2000	2005	2010	2020
Energy	**121**	**160**	**167**	**187**	**218**
Electricity Use (Consumption)	53.8	75.4	75.8	85.8	98.4
Transportation Fuel Use	39.7	52.7	59.4	66.4	81.5
Res/Comm/Other Ind. Fuel Use	27.3	30.9	31.8	34.5	38.5
Other	**14.8**	**21.1**	**25.2**	**27.7**	**37.2**
Industrial Processes	1.6	3.1	5.4	7.1	15.1
Agriculture	8.3	11.0	13.3	14.1	15.5
Waste Management	4.8	7.0	6.5	6.5	6.6
Gross Emissions (Consumption Basis)	**136**	**180**	**192**	**214**	**256**
Change relative to 1990		33%	42%	58%	88%
Change relative to 2000			7%	19%	42%
Forestry	**–23.2**	**–23.7**	**–23.7**	**–23.7**	**–23.7**
Net Emissions (Consumption Basis, Including Forest Sink)	**112**	**156**	**169**	**191**	**232**
Change relative to 1990		39%	50%	70%	106%
Change relative to 2000			8%	22%	48%
Per Capita Gross Emissions	**20.5**	**22.4**	**22.1**	**22.7**	**23.4**

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

Historical Emissions

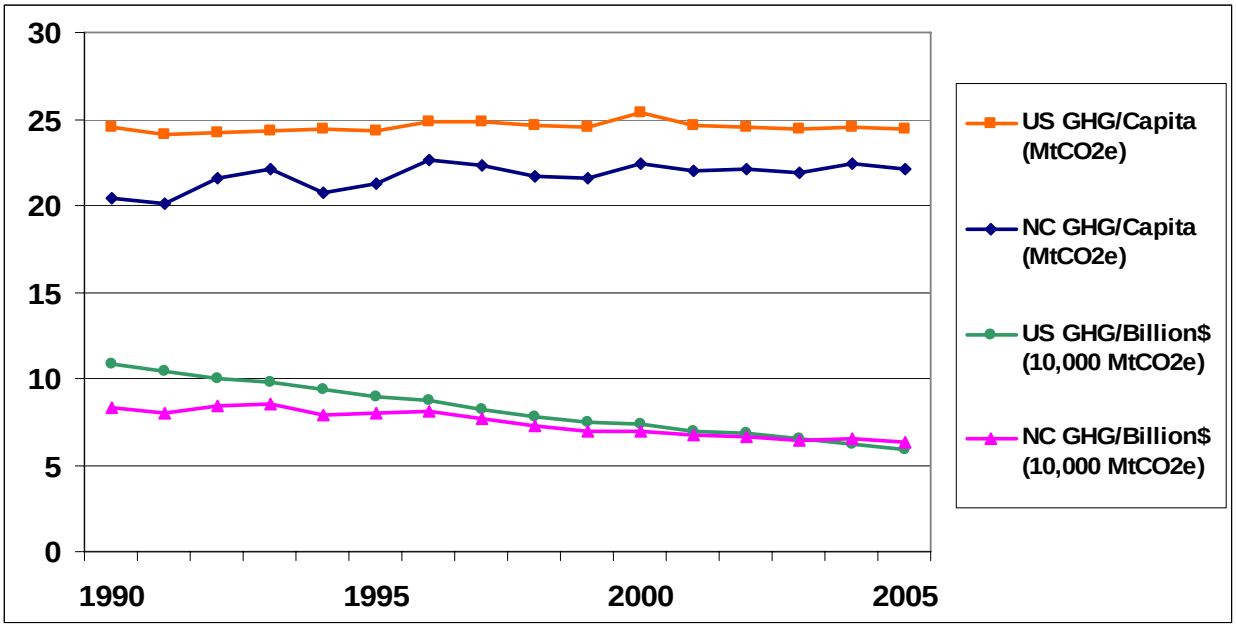
Overview

In 2000, on a gross emissions consumption basis (i.e., excluding carbon sinks), North Carolina accounted for approximately 180 million metric tons (MMt) of carbon dioxide equivalent (CO_2e) emissions, an amount equal to 2.5% of total United States (U.S.) gross GHG emissions. On a net

emissions basis (i.e., including carbon sinks), North Carolina accounted for approximately 156 $MMtCO_2e$ of emissions in 2000, an amount equal to 2.4% of total U.S. net GHG emissions.[4] North Carolina's GHG emissions are rising more quickly than those of the nation as a whole. From 1990 to 2000, North Carolina's gross and net GHG emissions were up 33% while national gross emissions rose by 16% during this period.[5]

On a per capita basis, North Carolinians emitted about 22 metric tons (Mt) of gross CO_2e in 2000, less than the national average of about 25 $MtCO_2e$. Figure 2-1 illustrates the state's emissions per capita and per unit of economic output. It also shows that, like the nation as a whole, per capita emissions have remained fairly flat, while economic growth exceeded emissions growth throughout the 1990–2002 period. From 1990 to 2000, emissions per unit of gross product dropped by 32% nationally and by 17% in North Carolina.[6]

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



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

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

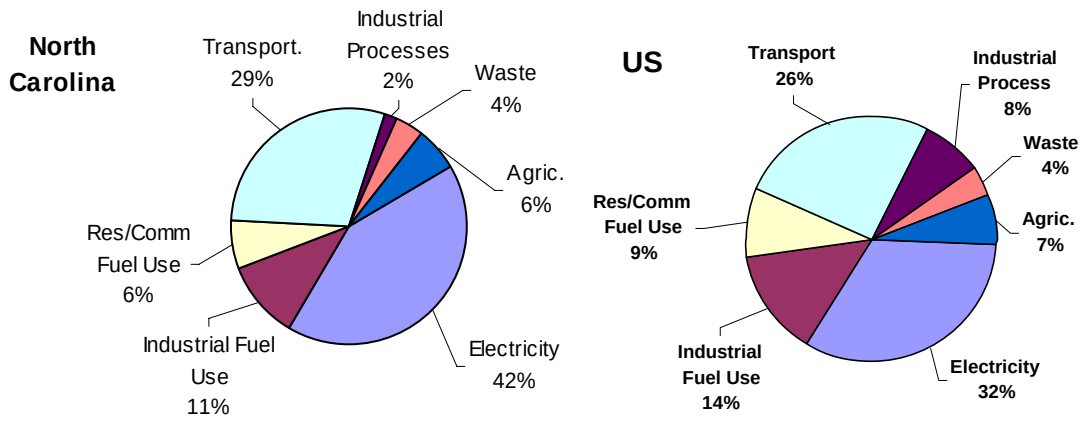
[5] During the 1990s, population grew by 21% in North Carolina compared with 13% nationally. Furthermore, North Carolina's economy grew faster on a per capita basis (up 60% vs. 52% nationally).

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

[7] *Gross* emissions estimates include only those sources with positive emissions. Carbon sequestration in soils and vegetation is included in *net* emissions estimates.

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

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



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

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

Agricultural activities such as manure management, fertilizer use, and livestock (enteric fermentation) result in CH_4 and N_2O emissions that account for another 6% of state GHG emissions. Industrial process emissions comprised about 2% of state GHG emissions in 2000, and these emissions are rising rapidly due to the increasing use of HFCs and PFCs as substitutes for ozone-depleting chlorofluorocarbons.[8] Other industrial processes emissions result from aluminum manufacturing; PFC use in semiconductor manufacture; CO_2 released during soda ash, limestone, and dolomite use; and SF_6 released from transformers used in electricity transmission and distribution systems. Landfills and wastewater management facilities produce CH_4 and N_2O emissions accounting for the remaining 4% of the state's gross GHG emissions in 2000.

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

As shown in Figure 2-2, electricity use in 2000 accounted for 42% of North Carolina's gross GHG emissions (about 75 $MMtCO_2e$), which is higher than the national share of emissions from electricity production (32%). On a per capita basis, North Carolina's GHG emissions from electricity consumption are higher than the national average (in 2000, 9.4 $MMtCO_2e$ per capita vs. 8.1 $MMtCO_2e$ per capita nationally). The average North Carolinian used more electricity than the average U.S. resident (15,000 kilowatt-hours [kWh] per person per year compared with 12,000 kWh nationally in 2000). During the 1990s, electricity demand grew at a rate of 2.9% per

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

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

As noted above, these electricity emissions estimates reflect the *GHG emissions associated with the electricity sources used to meet North Carolina demands,* corresponding to a consumption-based approach to emissions accounting. For many years, North Carolina power plants have tended to produce less electricity than is consumed in the state; in the year 2000, for example, North Carolina imported 8% of the electricity consumed in the state. As a result, in 2000, emissions associated with electricity consumption (75 $MMtCO_2e$) were higher than those associated with electricity production (70 $MMtCO_2e$).[9]

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

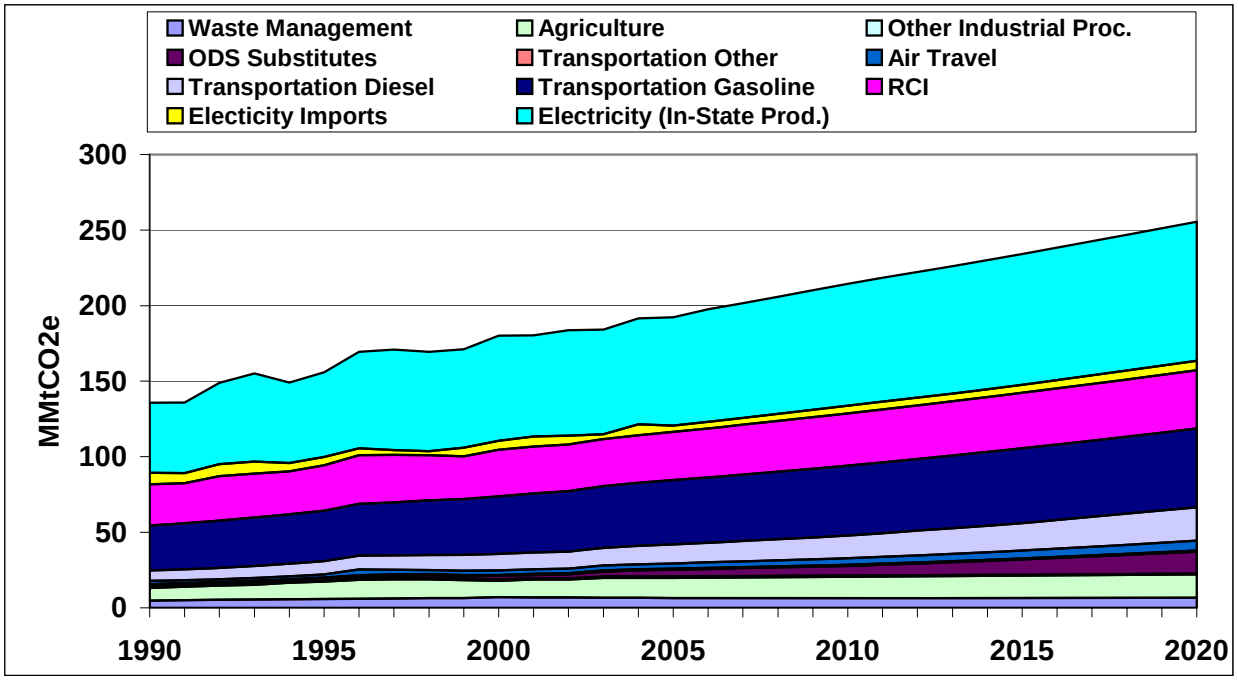
Like electricity emissions, GHG emissions from transportation fuel use have risen steadily from 1990 to 2005 at an average rate of 2.7% annually. Gasoline-powered vehicles accounted for about 72% of transportation GHG emissions in 2000. Diesel vehicles accounted for another 21% in 2000, air travel for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

Reference Case Projections

Relying on North Carolina agency projections of electricity and fuel use and other assumptions noted in the *Inventory and Projections* report, a simple reference case projection of GHG emissions through 2020 was developed. As illustrated in Figure 2-3 and shown numerically in Table 2-1, under the reference case projections, North Carolina's gross GHG emissions continue to grow steeply, climbing to 256 $MMtCO_2e$ by 2020, 88% above 1990 levels. Electricity is projected to be the largest contributor to future emission growth by far, followed by HFCs and PFCs used in place of ozone-depleting substances (ODS), as shown in Figure 2-4. Other major sources of emissions growth include transport (diesel), gasoline, and fuel use in buildings and industry (RCI). For the electricity supply sector, the increase in emissions after 2010 appears largely as the result of emissions associated with natural gas used to generate electricity by facilities in-state and emissions associated with electricity imported into North Carolina to meet North Carolina's demand for electricity (see Figure 2-5). After 2010, the use of coal and oil to generate electricity in-state is projected to remain at 2010 levels.

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

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



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

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

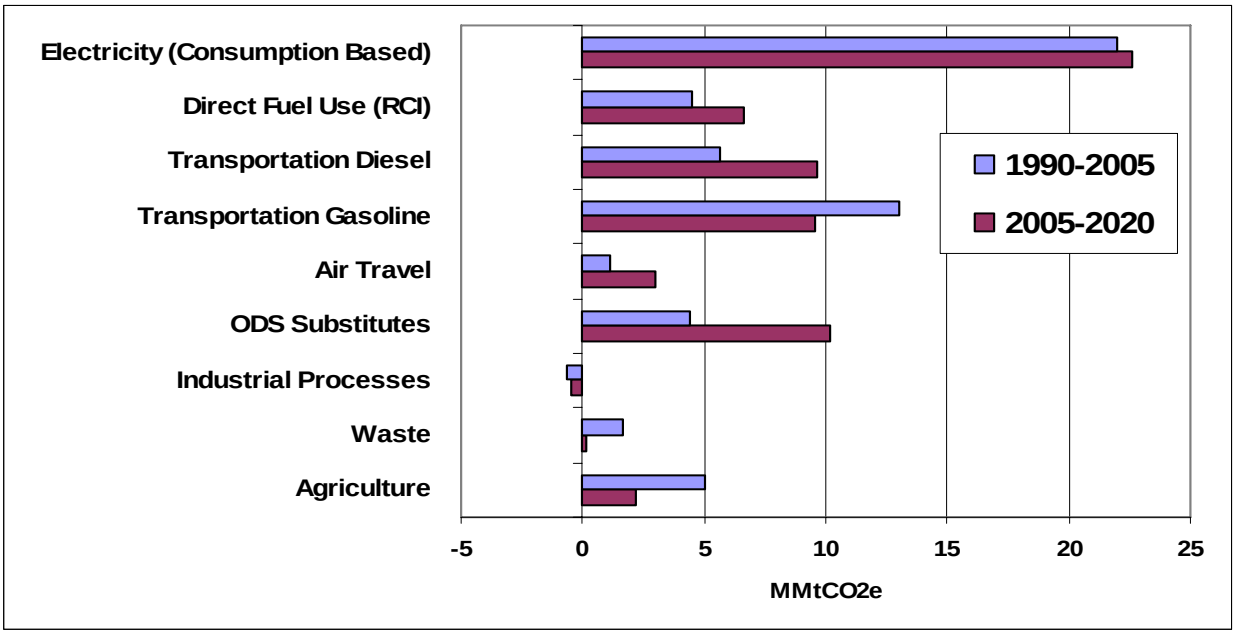
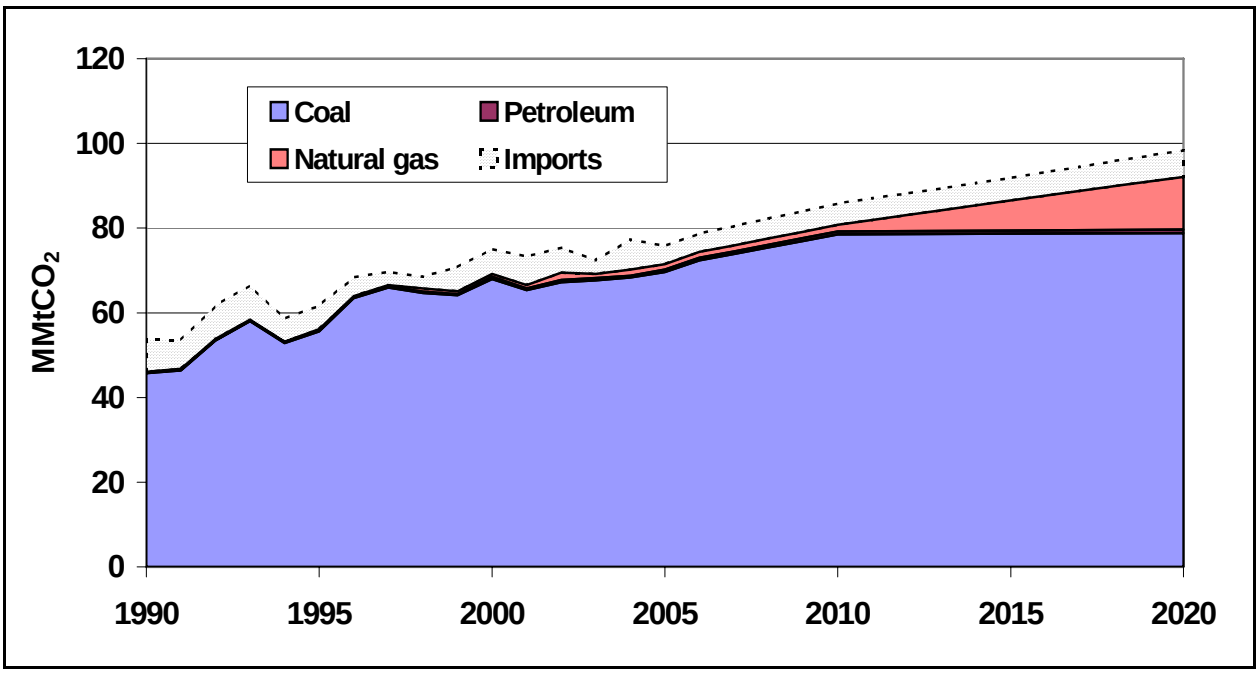
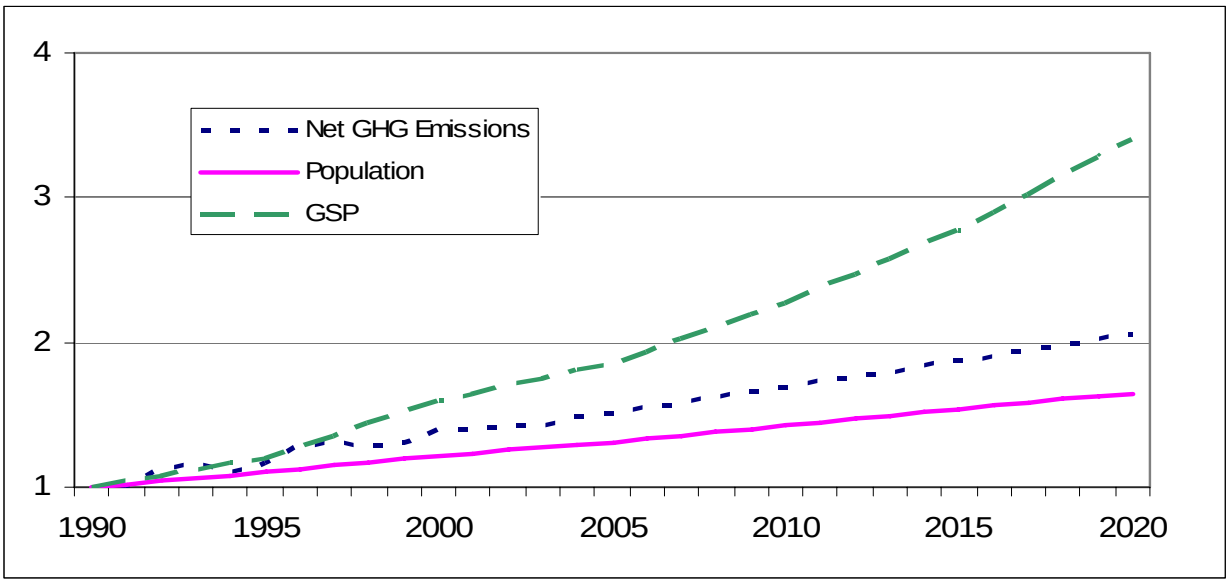


Figure 2-5. Emissions from electricity consumption in North Carolina, by fuel source



Note: Emissions associated with electricity generated from biomass are not shown in this graph because of scale effects. Emissions associated with biomass combustion are estimated to be about 0.03 $MMtCO_2e$ from 2003 through 2020.

Figure 2-6. North Carolina historical and projected net GHG emissions, gross state product, and population (indexed to 1990 value, measured in $MMtCO_2e$)



CAPAG Revisions

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

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

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

Table 2-2 shows the change in emissions representing the difference between the revised emissions minus the draft emissions. Overall, the revisions approved by the CAPAG lowered 1990 emissions by 2.9 $MMtCO_2e$, 2005 and 2010 emissions by 3.9 $MMtCO_2e$, and 2020 emissions by 11.4 $MMtCO_2e$.

Table 2-2. Revisions to inventory and reference case projections ($MMtCO_2e$)

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

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

Key Uncertainties

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

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

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

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

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

Chapter 3
Residential, Commercial, and Industrial Sectors

Overview of Greenhouse Gas Emissions

The residential, commercial, and industrial (RCI) sectors are directly responsible for almost one-fifth of North Carolina's current gross greenhouse gas (GHG) emissions (37 million metric tons (MMt) of carbon dioxide equivalent (CO_2e) in 2005). Direct emissions of GHGs from the RCI sectors result principally from the on-site combustion of natural gas, oil, and coal plus non-energy sources of GHG emissions – primarily leaks of methane from natural gas transmission and distribution pipelines, the release of CO_2 and fluorinated gases (PFCs) during industrial processing (largely from the aluminum production, soda ash consumption, and semi-conductor industries), the use of sulfur hexafluoride (SF_6) in the utility industry, and the leakage of hydrofluorocarbons (HFCs) from refrigeration and related equipment.[1]

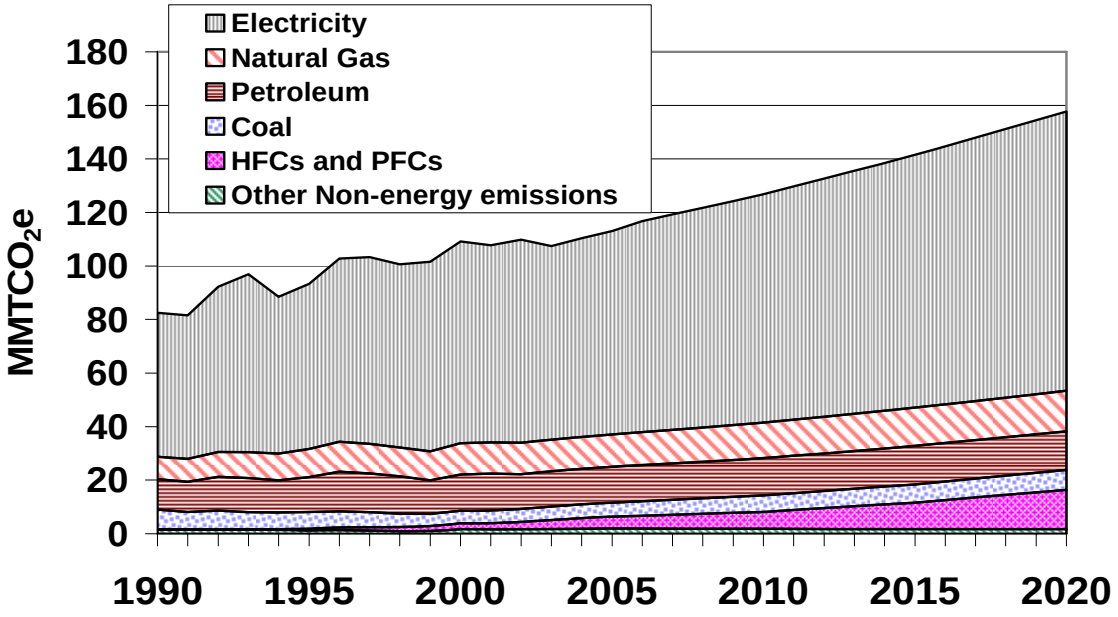
Considering only the direct emissions that occur within buildings and industries, however, ignores the fact that virtually all electricity sold in North Carolina is consumed as the result of activities in the residential, commercial, and industrial sectors. If the emissions associated with producing the electricity consumed in North Carolina are considered, RCI activities are associated with well over half (about 60% of the state's gross GHG emissions.[2] The State's future GHG emissions therefore will depend heavily on future trends in the consumption of electricity and other fuels in the RCI sectors.

Figure 3-1 shows historical and projected RCI GHG emissions by fuel and source, and illustrates the large fraction of RCI emissions associated with electricity use. RCI emissions associated with electricity and natural gas use are expected to rise by nearly 30% between 2005 and 2020, and are projected to account for over 40% of the State's growth in gross GHG emissions during this period.

[1] RCI direct fuel use accounted for 31.8 MMtCO_2e in GHG emissions in 2005, while industrial process emissions accounted for emissions totaling 5.4 MMtCO_2e.

[2] Gross emissions here denote greenhouse gas emissions from activities in North Carolina, adjusted for exports of electricity, but not including consideration of estimated "sinks" of greenhouse gases in the forestry and land-use sectors.

Figure 3-1. Historical and projected RCI GHG emissions by fuel and process in North Carolina, 1990 to 2020



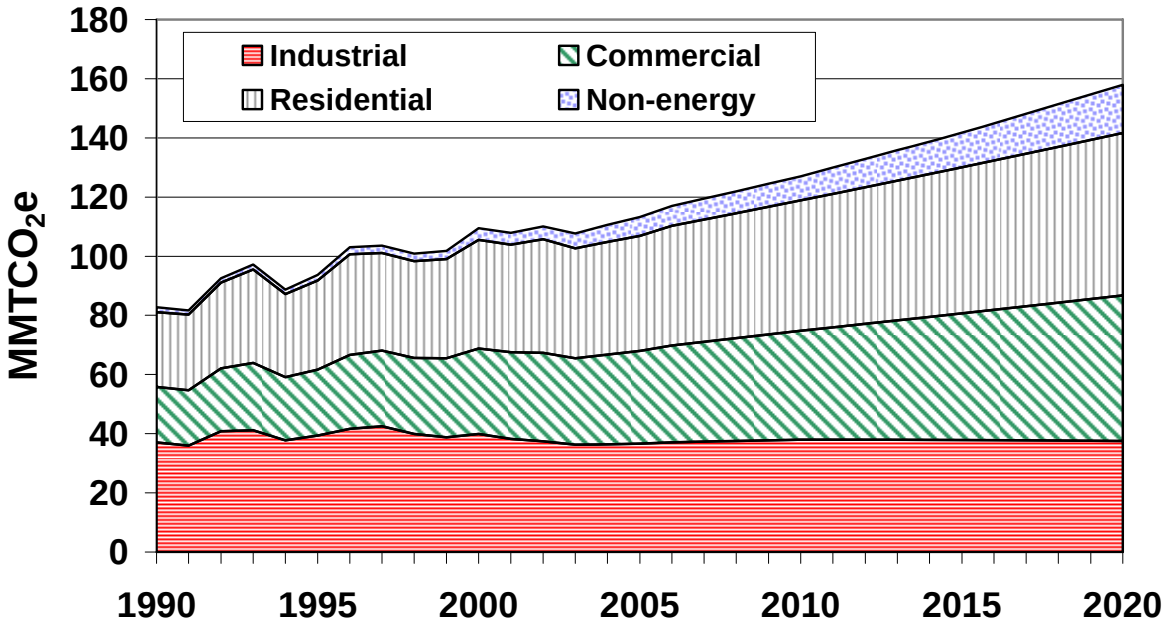
PFCs = perfluorocarbons; HFCs = hydrofluorocarbons.

Since 1990, overall GHG emissions associated with energy consumption in the residential and commercial sectors have grown steadily. This growth is projected to continue, driven by both population growth and increasing commercial activity (as indicated in Figure 3-2). The total emissions from electricity and fuels consumption in the industrial sector have varied, showing increases or and decreases year-to-year, in the years since 1990, but show only a very slight overall reduction from 1990 to 2005.[3] The GHG emissions from industrial sector electricity and fuels use are expected to grow modestly through 2010, and decline slightly thereafter, so that 2020 emissions are projected to be about 2.5% higher than emissions in 2005. Non-energy emissions grew by a factor of more than 3 between 1990 and 2005, largely as a result of increased emissions from HFC use. This trend in non-energy emissions is expected to accelerate in the future. Non-energy emissions are projected to increase by over 8% per year from 2005 to 2020 – increasing from 2% of total gross GHG emissions in 2000 to almost 6% in 2020. Increased use of HFCs for refrigeration, air conditioning and other uses, as substitutes for ozone depleting substances, are the main source of the projected emissions increases. Even low amounts of HFCs, from leaks and other releases under normal use of the products, can lead to high GHG emissions in CO_2-equivalent terms, due to the high global warming potential of these

[3] This reduction was largely the result of changes in North Carolina industrial activity and processes, rather than direct emissions reduction efforts. GHGs have not historically been considered pollutants or regulated in the same way that "criteria pollutants" (local and regional air pollutants such as oxides of sulfur and nitrogen) or hazardous air pollutants, and no post-combustion control/removal devices are commonly in use for CO_2, the major GHG species.

substances.[4] Figure 3-2 shows the estimated contribution of the individual sectors to RCI emissions over time.

Figure 3-2. 1990–2020 GHG emissions by sector and source



Key Challenges and Opportunities

The principal means to reduce RCI emissions in North Carolina include improving energy efficiency, substituting for electricity and natural gas with lower-emission energy resources (such as wind, solar water heating, photovoltaics, and biomass), reducing industrial-sector process (non-energy) emissions, increasing distributed (consumer-sited) electricity generation based on renewable fuels and on combined heat and power, and various strategies to decrease the emissions associated with electricity production (see Chapter 5, Energy Supply, for the latter). The state's limited implementation of energy efficiency programs and related initiatives in past years, relative to some other states that have aggressively pursued efficiency programs, provides a challenge—in rapidly assembling capacity to harvest energy efficiency resources—but also strong opportunities to reduce emissions through programs and initiatives to improve the efficiency of buildings, appliances, and industrial practices. An excellent start to building such programs and initiatives has been provided by the efforts of the State Energy Office (see, for example, the listing of Energy Office and other ongoing programs in NC provided in Annex A to the RCI Options Descriptions provided as Appendix E, by the recent Duke Energy and Progress

[4] Projections of energy consumption in the RCI sectors are based on *NC Energy Outlook 2003*. Prepared by Global Insight for the State Energy Office, North Carolina Department of Administration, May 2003. Projections for emissions from HFC use are Growth rates are based on growth in projected national emissions from U.S. Department of State, *U.S. Climate Action Report 2002*, Washington, DC, May 2002. See http://yosemite.epa.gov/oar/globalwarming.nsf/UniqueKeyLookup/SHSU5BNQ76/$File/ch5.pdf

Energy announcements that they will significantly expand their energy efficiency programs, by the recent passage of Senate Bill 3,[5] and by programs outlined in the State Energy Plan (see below). At the same time, North Carolina's robust population and economic growth, and the North Carolina's leaders' growing commitment to carry out significant emissions reductions, places pressure on communities and businesses in North Carolina to make swift decisions to put in motion changes that will reduce emissions. A key challenge lies in the design and implementation of strategies that address State goals and thus ensure that new buildings and industries take full advantage of opportunities to reduce energy use and emissions.

Though overall investment in energy efficiency to date has been limited relative to that in a number of other states, there are a number of existing programs in North Carolina that can readily be built upon to reduce greenhouse gas emissions. These include a number of programs and initiatives through the North Carolina State Energy Office (to be expanded by recent legislation), including programs related to energy efficiency, training and certification of energy sector professionals, and others. Local organizations have provided building and industrial energy technical assistance (energy audits) for many years, and the North Carolina Greenpower program, offering consumers electricity generated from renewable sources, is ongoing. A systems benefit charge-funded program for energy efficiency and other services has likewise been operating in the State for many years, and several utilities have programs addressing energy efficiency through provision of low-interest loans and direct incentives. The State Energy Plan, first updated and published in 2003 and revised in 2005 (further updates are currently underway), identifies a strong list of initiatives to increase energy efficiency in the RCI sectors and in other areas of the North Carolina economy.[6] While an indication of the growing efforts for improving efficiency and reducing emissions in North Carolina, these programs need to be further supported and extended to realize the overall potential of the state to slow its growth of energy use and emissions of GHG pollutants.

Overview of Mitigation Recommendations and Estimated Impacts

The CAPAG recommends a set of 11 mitigation options for the residential, commercial, and industrial sectors (including industrial process emissions from sources other than energy use) that offer the potential for major economic benefits and emissions savings. As summarized in Figure 3-3, these mitigation options, if fully implemented, could lead to emissions savings from reference case projections of 33 $MMtCO_2e$ per year by 2020, and cumulative savings of 219 $MMtCO_2e$ from 2007 through 2020.[7] The mitigation options recommended could result in net

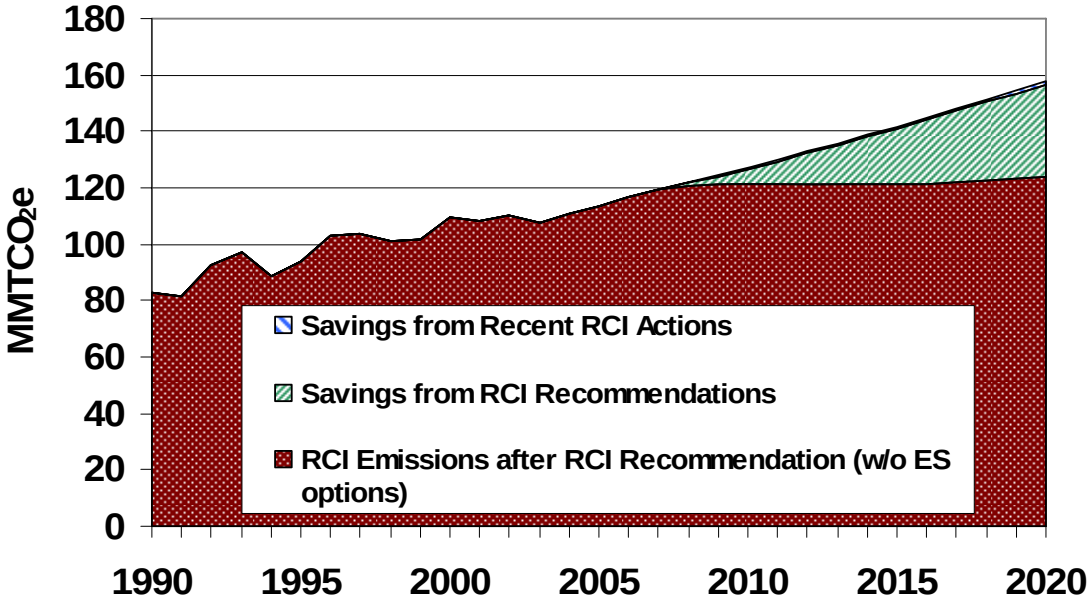
[5] See, for example, http://www.ncleg.net/Sessions/2007/Bills/Senate/HTML/S3v6.html. Senate Bill 3, among other provisions, includes "Renewable Energy and Energy Efficiency Standards (REPS) for Electric Public Utilities." This bill passed in August 2007 and has been signed into law.

[6] See *North Carolina State Energy Plan*, prepared for the North Carolina Energy Policy Council by the State Energy Office, North Carolina Department of Administration and Appalachian State University Energy Center (Revised edition January 2005), available at http://www.energync.net/epc/docs/Energy%20Plan%202005.pdf

[7] Note that these figures do not include additional emission savings from recent actions that were not already accounted for in the reference case projections. See the Appendix E for more detailed information on these options, including details of how costs and savings of the options were calculated. Of the total 219 $MMtCO_2e$ in cumulative emissions savings from the RCI policies, 211 $MMtCO_2e$ are from reduced electricity consumption, 8 $MMtCO_2e$ are from the reduction in on-site use of fossil fuels, though the latter total does not include avoided heating fuel savings from implementation of combined heat and power systems.

cost *savings* of nearly $4.0 billion through the year 2020 on a net present value basis (NPV).[8] Most emissions savings from the RCI options are in the form of reduced carbon dioxide emissions, with relatively minor reductions of emissions of other greenhouse gases (principally methane and nitrous oxide) produced via leakage and/or combustion of fuels.

Figure 3-3. Impact of CAPAG mitigation option recommendations on RCI emissions



The estimated impacts of the RCI mitigation options recommended by the CAPAG are shown in Table 3-1.[9] Also shown in Table 3-1 are the results of several ongoing initiatives in North Carolina. These "Savings from Recent RCI Actions" are not accounted for in the reference inventory and forecast, but contribute to overall emissions reduction along with savings from the CAPAG-recommended measures. The combination of savings from recent actions and CAPAG mitigation options are, in the RCI sectors, estimated to be approximately the same as the projected reference case growth in emissions from 2007 through 2020, as shown by the trend in the dark area in Figure 3-3.

The CAPAG mitigation option recommendations described briefly here, and in more detail in Appendix E, result not only in significant emissions and costs savings, but offer a host of additional benefits as well. These benefits include – but are by no means limited to – potential investments in other areas of the economy as a result of reduced spending on energy by homeowners and businesses, contributions to local economic development, job growth, and

[8] The net cost savings are calculated based on options costs that include fuel expenditures, operations, maintenance, and administrative costs, plus amortized, incremental equipment (capital) costs, less the costs of fuels and electricity that are saved as a result of implementation of RCI options. All NPV values described have been calculated using a 5% annual real discount rate.

[9] Note that "UC" in the right hand "Level of Support" column of Table 3-1 indicates that the option was recommended by the CAPAG by unanimous consent of the CAPAG members present at the meeting where the option was reviewed.

enhancement of productivity, reduced local air pollution and related reduced impacts of air pollution on human health, reduction in the needs for and costs of electricity transmission and distribution system additions, and improvements in comfort, convenience, and indoor air quality as a result of building improvement measures.

In order for the RCI mitigation options recommended by the CAPAG to yield the levels of savings described here, the options must be implemented in a timely, aggressive, and thorough manner. This means, for example, not only putting the options themselves in place, but attending at the same time to the development of "supporting options" that are needed to help make the recommended options effective. Many of these supporting mitigation options are a part of the package of RCI options, while others are included among the mitigation options recommended as "cross-cutting" options (see Chapter 7), and/or in options recommended in other chapters of this report (most notably, in the case of RCI, in the Energy Supply Chapter). Improved building energy codes (RCI-6) will not be optimally effective, for example, without further support and intensified training of contractors, builders, architects, financial institutions, and building inspectors, among others, in the methods and benefits of efficient building design, and of building code enforcement (as recommended, in part, in RCI-8). Given that the way that energy-efficiency improvements made as buildings are constructed will save energy over the entire, often long, lifetime of those buildings, modest investments now in building codes, training for building sector professionals, and code enforcement will yield significant cost, energy, and GHG emissions savings for decades. Regulatory changes that provide incentives and lower disincentives for the adoption of consumer-sited combined heat and power and renewable electricity generation are also among the supporting initiatives crucial to the success of the RCI options recommended by the CAPAG; some of these options are already in the formative stages in North Carolina. The CAPAG's work indicates that there are considerable benefits to both the environment and to consumers from adoption of the mitigation options recommended, but careful, comprehensive, and detailed planning and implementation, as well as consistent support (building on existing North Carolina programs and capacity whenever possible), of these options, and the initiatives and activities that they include, will be required if these benefits are to be achieved.

Table 3-1. CAPAG-recommended GHG emissions mitigation options and results for the RCI sectors

Option No.	Mitigation Option Name	GHG Reductions ($MMtCO_2e$)			Net Present Value 2007–2020 (Million $)	Cost-Effective-ness ($/$tCO_2e$)	Level of Support
		2010	2020	Total 2007–2020			
	Residential, Commercial, and Industrial						
RCI-1	Demand Side Management Programs for the Residential, Commercial and Industrial Sectors	1.9	11.6	77.1	–1,895	–25	UC
RCI-2	Expand Energy Efficiency Funds	1.5	8.0	54.8	–1,346	–25	UC
RCI-3	Energy Efficiency Requirements for Government Buildings	0.0	1.1	6.4	–88	–14	UC
RCI-4	Market Transformation and Technology Development Programs	0.0	2.0	10.5	–339	–32	UC
RCI-5	Improved Appliance and Equipment Efficiency Standards	0.0	1.0	5.3	–336	–63	UC
RCI-6	Building Energy Codes	0.5	3.5	23.1	–400	–17	UC
RCI-7	"Beyond Code" Building Design Incentives and Targets, Incorporating Local Building Materials and Advanced Construction	0.7	5.2	34.2	–494	–14	UC
RCI-8	Education (Consumer, Primary/Secondary, Post-Secondary/ Specialist, College and University Programs)	*Not quantified*					UC
RCI-9	Green Power Purchasing (required for state facilities) and Bulk Purchasing Programs for Energy Efficiency or Other Equipment	0.1	0.5	3.5	11	3	UC
RCI-10	Distributed Renewable and Clean Fossil Fuel Power Generation	1.2	4.6	33.5	392	12	UC
RCI-11	Residential, Commercial, and Industrial Energy and Emissions Technical Assistance and Recommended Measure Implementation	0.5	2.1	14.9	–494	–33	UC
	Sector Total, after adjusting for overlaps	**5.3**	**33.0**	**218.7**	**–3,994**	**–18**	**N/A**
	Reductions From Recent Actions (see table below)*	**0.5**	**1.2**	**10.1**			
	Sector Total Plus Recent Actions	**5.8**	**34.2**	**228.8**			**N/A**

Emissions reductions associated with recent actions (and not included in reference case projections) that are related to RCI mitigation options

Option No.	Mitigation Option	Estimated 2010 GHG Reduction ($MMtCO_2e$)	Estimated 2020 GHG Reduction ($MMtCO_2e$)	Cumulative 2007–2020 GHG Reduction ($MMtCO_2e$)
RCI-1	Demand Side Management Programs for the Residential, Commercial and Industrial Sectors	0.3	0.7	6.2
RCI-2	Expand Energy Efficiency Funds	0.2	0.4	3.6
RCI-6	Building Energy Codes	0.0	0.0	0.0
RCI-9	Green Power Purchasing (required for state facilities) and Bulk Purchasing Programs for Energy Efficiency or Other Equipment	0.0	0.0	0.3

UC = unanimous consent; N/A = not applicable.

Negative values in the Net Present Value and the Cost-Effectiveness columns represent net cost savings associated with the options.

* “Recent actions” represent initiatives undertaken in North Carolina that reduce GHG emissions that were implemented shortly before or during the CAPAG process. The emission reductions associated with recent actions are not accounted for in the GHG emissions inventory and reference case projections. Emissions reductions associated with these recent actions were therefore estimated separately, and are counted toward overall statewide reductions along with reductions from the mitigation options recommended by the CAPAG.

Residential, Commercial, Industrial (RCI) Mitigation Option Descriptions

The Residential, Commercial, Industrial Sectors include emissions reduction opportunities related to improving energy (and sometimes water) use efficiency, using lower-GHG energy sources, and increasing consumer-sited renewable electricity generation and use of combined heat (and/or cooling) and power (CHP) systems. Additional detail on each of the options summarized below can be found in Appendix E.

RCI-1 Demand-Side Management Programs for the Residential, Commercial, and Industrial Sectors

The CAPAG recommends that Demand-side Management (DSM) programs funded by gas and electric utilities in North Carolina be expanded to yield higher levels of energy savings, demand response, and greenhouse gas emissions savings. Utility-funded DSM programs reduce either the consumption of or the demand for conventional sources of electricity and fossil fuels. Examples of DSM programs include technical assistance for and implementation of energy efficiency and renewable energy measures, electrical (and in some cases fuel) demand responses, alternative rate schedules, and research activities. The goal for this option is to reach a level of DSM investment in North Carolina equal to 1.5% of utility revenues by 2012. This option is designed to work in tandem with other strategies recommended by the CAPAG, including options described in other Chapters in this Report, which can also encourage efficiency gains.

Specific recommendations from the RCI TWG include proposing that the North Carolina General Assembly and the North Carolina Utilities Commission take an active role in encouraging the investor-owned, cooperative and municipal utilities to pursue active DSM programs.

Examples of utility-funded programs that this option supports include:

- Residential building programs—including programs to promote higher efficiency new and existing homes, and the expanded use of renewable energy in residences, with specific programs focused on the often under-served low-income and rental properties segments;[10]
- Commercial and industrial building programs, including efficiency programs for new and existing buildings, and renewable energy programs for commercial and industrial buildings; and
- Multi-sector strategies, including demand response and demand reduction programs, technical assistance, education, training, consumer outreach, and promotional activities to support the DSM programs, and grants, loans, performance contracting arrangements, and

[10] See the RCI Options Descriptions in Appendix E, and the discussion of existing programs in these areas developed by the State Energy Office, Appalachian State University, and others provided in Annex A to Appendix E.

other incentive programs to provide financial support or incentives for implementation of DSM programs.

RCI-2 Expand Energy Efficiency Funds

The CAPAG recommends that North Carolina's existing Public Benefits Charge be significantly increased to support more investments in energy efficiency and renewable energy options. The public benefits charge (sometimes call systems benefits charge) is a fee assessed to utility customers based on their usage of energy in a given time period. With deregulation in many states, utility commissions often lose the ability to require the electric utilities to have efficiency programs. The result in many states is the development of the public benefits charge, which is a non-bypassable charge on electric bills. The funds collected are then provided to a third party to provide energy efficiency programming. The CAPAG recommends that these increased public benefits charges be collected under the oversight of the NC Utilities Commission, and invested in residential, commercial, and industrial energy efficiency and renewable energy programs through one or more third-party administrators. Long-term consistency in management and dedicated application of funds collected via public benefits charges to the target programs will be crucial to the success of this initiative.

Investments in energy efficiency and renewable energy made using public benefits funds would be expected to span a wide variety of residential, commercial and industrial applications.

The CAPAG set the goal of this option as providing public benefit charges adequate to implement energy efficiency and renewable energy programs comparable to the more effective public benefits charge-funded programs in the United States. Based on information on energy efficiency programs in other states, 1% of utility revenues was chosen as an appropriate public benefits charge goal for North Carolina at present.[11]

RCI-3 Energy Efficiency Requirements for Government Buildings

Recognizing that governments should "lead by example" the CAPAG recommends that energy use targets be set and worked toward to improve the efficiency of energy use in State and local government buildings. This option sets energy-efficiency goals for the existing government building stock, as well as for new construction and major renovations of government buildings.[12]

Elements of this option include:

- Adherence by new and renovated government buildings to specific energy-related guidelines providing considerable improvement in building energy performance relative to standard practice, with a specific goal of reducing the energy consumption per square foot of government building area in North Carolina by 20% by 2027.

[11] The recently enacted Senate Bill 3, as referenced above, includes some similar elements to those proposed in this option.

[12] Note that some of the elements of this option have been included in the recently-signed Senate Bill 668, "Energy Conservation in State Buildings." See http://www.ncleg.net/Sessions/2007/Bills/Senate/HTML/S668v6.html

- Revising administrative policies as needed to provide incentives for government organizations to invest in increased energy-efficient construction or building alterations.
- Extending green campus initiatives to all public academic and government campuses.
- Energy benchmarking, measurement, and tracking programs for municipal and state buildings.
- Energy efficiency and renewable energy requirements for new, renovated, and existing government buildings.

RCI-4 Market Transformation and Technology Development Programs

The CAPAG recommends that North Carolina develop long-term and robust market transformation and technology development programs. Such programs must provide 1) consistent and enduring support for technology improvement and incorporation, 2) continued investment in technology development and integration, and 3) independent evaluation of the efficacy of the technologies.

This recommendation is broadly defined and does not address a particular technology or market. Rather, it addresses a method for bringing appropriate technologies and processes to the marketplace. Defined as such, the CAPAG recommends that the following components be included in market transformation strategies for North Carolina, though others can and should be included as well:

- Expand existing programs to promote the appropriate use of premium motors and drives in industrial applications.
- Provide renewed and intensified support for implementation of renewable energy applications such as solar water heaters.
- Target the early retirement of older appliances using a “bounty” program.
- Provide support for processes that recover waste heat from industrial applications, and promote the use of ground-source heat pumps by helping to identify and qualify appropriate applications in the residential, commercial and industrial sectors.
- Encourage national legislators to provide increased federal funding for the U.S. Environmental Protection Agency’s ENERGY STAR program in order to identify and qualify a greater number of products under ENERGY STAR labeling.
- Encourage and enable smaller purchasers to act in aggregate groups to reduce costs and quantify emission reduction benefits from technology and process improvements. This could include, for example, setting up programs to organize consumers and to work with them to provide information resources to evaluate and take advantage of savings emissions reduction opportunities.
- Provide a continuous funding level for near-term research and deployment of energy efficient technologies and processes, including providing stable or expanded state funding for existing programs and new initiatives.

Implementation of market transformation programs requires the participation and buy-in of industry partners, regulatory bodies and consumer groups.

RCI-5 Improved Appliance and Equipment Efficiency Standards

The CAPAG recommends that North Carolina should replicate the appliance and equipment efficiency standards adopted in other states for appliances not covered by federal standards.[13] As part of this action, the CAPAG recommends that the State, working together with other states in, should advocate for stronger federal appliance efficiency standards where doing so is technically feasible and economically justified.[14]. Implementation of stronger-than-federal standards together with other states is much preferred by the CAPAG, as it provides a broader market for manufacturers and thus lowers net costs of higher-efficiency devices to North Carolina consumers. The CAPAG recommends that development of new standards start in 2010, with implementation starting in 2012.

Elements of this mitigation option include:

- Development of committee or other working group to develop recommendations on appliance standards (similar to, for example, the existing North Carolina group that considers building code changes).
- Adoption of State-level Appliance Efficiency Standards, defined sufficiently broadly to include, for example, commercial sector and information technology (IT) equipment.
- The CAPAG voices support for adoption of more stringent federal-level appliance efficiency standards, and recommends that North Carolina's congressional delegation and state government officials voice support for such standards.
- Design standards for recycling of materials in appliances, and include water use reduction as a criterion for appliance efficiency improvement.
- Assistance programs to help low-income consumers with purchase of appliances meeting more stringent standards, so as to reduce the higher-first-cost burden of higher-efficiency appliances on those consumers.
- Introduce elevated energy standards for appliances and equipment purchased by public agencies.
- Encourage state agencies, utilities, and other organizations involved in appliance and equipment efficiency programs to work with manufacturers to identify devices where significant savings are possible, and to consider cost and technical impacts on manufacturers—and how to address those impacts—when setting new standards.

[13] A few examples here of devices not currently covered by Federal standards are commercial boilers, distribution transformers, and AC to DC power supplies. See www.standardsasap.org and Appendix E.

[14] For example, where changes in efficiency can be implemented by manufacturers in such a manner that the value of energy savings, and perhaps eventually the value of GHG emissions savings, is greater than equal to the increased cost of production of the appliance or equipment.

RCI-6 Building Energy Codes

The CAPAG recommends that North Carolina upgrade the energy-efficiency provisions of its building codes, and hasten implementation of standards already adopted or awaiting adoption. Building energy codes specify minimum energy efficiency requirements for new buildings or for existing buildings undergoing a major renovation. As energy use (largely electricity and gas) in buildings in North Carolina accounts for about one-third of current emissions, amending the Building Codes to make the requirements for minimum energy efficiency levels in buildings more stringent will have a considerable immediate and ongoing impact in reducing building-sector greenhouse gas emissions.

An ongoing process of code amendments for new and renovated residential and commercial buildings is proposed as follows.[15]

- North Carolina should adopt more stringent building codes to improve the efficiency of energy use in buildings.
- North Carolina should move toward adopting innovative features of advanced codes being implemented in other states, such as lighting efficiency requirements in new homes that go beyond the codes in force, as appropriate to conditions in the State.
- Statewide enforcement of both existing and new building codes should be improved at all levels, and enforcement should be fully implemented within 6 months of statewide code adoption (if applicable).
- North Carolina should regularly update its energy codes to assure that they remain consistent with stringent codes in use nationally and internationally. A three-year cycle of code review and improvement could be timed to coincide with the release of national model codes.
- As appropriate, codes should be modified to remove obstacles to renewable energy use, daylighting and non-conventional energy-efficient building materials in buildings where applicable.
- Include programs of expanded, more accessible and intensified education for building inspectors and other building industry professionals to assure that the new codes are implemented and enforced.

The CAPAG recommends 95% enforcement of existing building energy codes by 2008, and establishment and similar enforcement of a new energy code by 2010 that requires new North Carolina residences and commercial/industrial buildings to be 20% more efficient than buildings meeting current national building energy codes.

[15] As with other RCI options, please see Appendix E for additional details on the suggested building code improvements.

RCI-7 "Beyond Code" Building Design Incentives and Targets, Incorporating Local Building Materials and Advanced Construction

Energy use in existing buildings and in non-government-funded new buildings must be substantially improved. The CAPAG recommends that incentives and targets be provided and developed to induce the owners and developers of new and existing non-government buildings to markedly improve the efficiency with which energy and other resources are used in those buildings, along with provisions for raising targets periodically and resources to help achieve the desired building performance. This option includes elements to encourage the improvement and review of energy use goals over time, and to encourage flexibility in contracting arrangements to encourage integrated energy and resource efficient design and construction.

Elements of this option include:

- Promotion and Incentives for "beyond code" construction, using programs of various types to focus on specific sectors (new home construction, apartments, low income housing, commercial new construction, commercial renovation construction, and others), with improved design and construction standards and guidelines addressing multiple aspects of resource conservation.
- Promotion of energy technologies include solar water heating and solar heating/cooling building technologies, solar photovoltaic power on commercial buildings and many new homes, solar hot water heaters on homes and other buildings, new and existing lighting building energy technologies, and other applicable new technologies.
- Promotion of energy education under this option in coordination with the programs noted in RCI-8.
- The goals of this option are to induce 5% of new residential buildings and 2% of new commercial buildings annually to go to "beyond code" energy use levels that improve energy performance over the average new building by 30%, to induce significant examples throughout the state of various building types that use 50% or less energy than is supported by the existing building code, and to provide incentives such that energy efficiency in 20% of existing buildings is increase by 15% by 2015, and energy efficiency in 20% of existing commercial building energy performance is increased by 20%. These goals are intended to be in addition to privately and publicly-sponsored efforts at "beyond code" construction now ongoing in North Carolina.

RCI-8 Education (Consumer, Primary/Secondary, Post-Secondary/Specialist, College and University Programs)

The CAPAG notes that the effectiveness of emissions reduction activities in many cases depends on providing information and education to consumers, as well as to future consumers (primary and secondary school students), regarding the energy and greenhouse gas emissions implications of consumer choices. As a consequence, the CAPAG recommends that consumer and primary/secondary schools education programs focused on these issues be created in North Carolina, or augmented and expanded where they exist already. In addition, in order to

effectively implement many of the other RCI options above, specific and targeted education (at the community college, university, and post-graduate levels), outreach, and licensing requirements will be required for professionals in a variety of building-related trades in order to ensure that those professionals have the expertise to support aggressive GHG mitigation options in North Carolina. State support for such programs will help to build a pool of trained professionals that will benefit the state for years to come.

Training and education activities under this option should be implemented so as to fully support other RCI options, and options in other areas as applicable, and should be timed and provided at levels appropriate so as to build understanding and awareness of energy and environmental issues, and human capacity in the field (skilled worker and professionals) so that capacity will be ready when needed by the people and businesses of North Carolina.

Elements of this option include training, education, and certification for builders and contractors, training and certification of building code and other officials in energy code enforcement, energy management training and training of building operators, continuing education for building design professionals, including architects, engineers, developers, contractors, urban planners, and realtors, energy efficiency and related education introduced at community colleges and trade schools, consumer education and consumer information programs (building on efforts to date by the State Energy Office, the NC Energy Research Center at Appalachian State University, and others), and introduction/augmenting of energy and environmental curricula in schools.

RCI-9 Green Power Purchasing (required for State facilities) and Bulk Purchasing Programs for Energy Efficiency or Other Equipment

The CAPAG recommends that the use of "green power" in North Carolina be significantly expanded, and that public- and private-sector programs for the bulk purchase of high-efficiency appliances and equipment be developed. "Green power" supplements the state's existing power supply with electricity generated from renewable resources like the sun, wind and organic matter. This option expands an existing voluntary North Carolina program by making green power purchases mandatory for State facilities. As part of this strategy, the CAPAG also recommends establishing a program for the bulk purchase of appliances and equipment with higher-than-standard energy efficiency by public agencies, and for the organization of similar bulk-purchase programs in the private sector.

The CAPAG recommends that State facilities purchase energy through NC GreenPower or a similar green power provider to cover 20% of their power needs by 2018, over and above the requirements of renewable generation within an Environmental Portfolio Standard or similar requirement applying to electricity suppliers. This target would be phased in starting in 2008. Additionally, for bulk purchases, the CAPAG recommends a program to address purchases of 10% of electricity-consuming equipment purchased annually by state agencies, and 1% of electricity-consuming equipment purchased annually by all commercial/institutional sector consumers. Devices purchased under the energy efficiency bulk purchase program would have a target consumption of 20% less electricity, on average, than devices that would otherwise have been purchased.

RCI-10 Distributed Renewable and Clean Fossil Fuel Power Generation

The CAPAG recommends that implementation of distributed renewable and clean fossil fuel power generation systems of less than 10 MW be encouraged through a combination of regulatory changes and incentive programs. Distributed generation with clean power systems reduces fossil fuel use and greenhouse gas emissions as well as providing electricity system benefits.[16] Elements of this program include:

- Review existing net-metering policies (or check that the most recent North Carolina reviews of these policies are complete), including policies that affect electricity consumers who install on-site combined heat and power or distributed generation fueled with renewable or fossil fuels.
- Review as needed, and in consultation with the NC Utilities Commission, rate issues in NC, including the potential for decoupling of utility revenues from sales and rate design, with a specific focus on the impacts of rate design on greenhouse gas emissions.
- Provide incentives, including, as needed, increasing existing tax and utility incentives, for renewable energy applications such as photovoltaics and other renewable power sources, sufficient to reach the renewable energy development goals below.
- Promote clean combined heat and power in all sectors through, for example, a combination of utility incentives, information provision, streamlining of connection requirements, providing low-interest loans, and/or tax credits for potential hosts/owners/developers of these systems.
- Funding of research and development for distributed renewable and clean fossil fuel power generation, and provide direct or indirect support for in-state commercialization and production of new or advanced technologies for distributed renewable and clean fossil fuel power generation.
- Encourage the development of building-integrated distributed renewable and clean fossil-fuel power generation.

The goal of the program would be to implement 25%–33% of North Carolina's combined heat and power potential by 2020. An additional 2% to 4% of all NC homes will have solar hot water installations by 2020. This option also includes the goal of implementing 35 additional MW of distributed renewable generation over and above renewable portfolio standard-related new generation by 2020.

RCI-11 Residential, Commercial, and Industrial Energy and Emissions Technical Assistance and Recommended Measure Implementation

The CAPAG recommends that technical assistance be provided to help identify options for energy consumers to reduce fossil energy use and to reduce non-energy emissions of GHGs, and that consumers be provided with information and incentives allowing them to follow-up on that

[16] Electric system benefits can include, for example, reducing the need for transmission and distribution capacity by providing generation at the local level, and providing voltage and frequency support.

assistance to implement recommended measures. This initiative may include the following elements:

- Residential energy technical assistance for existing homes that identifies the most cost-effective energy efficiency measures for the individual homes visited. The technical assistance program can include diagnostic testing and analysis specific to the features of the home being investigated. The results reported to the homeowner can provide estimates of energy use, energy cost savings, and reductions in emissions due to implementation of the recommended measures.
- Commercial energy technical assistance for existing commercial buildings similar to the residential services, but most likely not including diagnostic testing. The analysis associated with technical assistance can also consider the benefit to the individual businesses visited of being served under alternative utility rate structures and of taking advantage of load control opportunities.
- Industrial energy technical assistance that identifies key efficiency measures, such as process heat changes, motor efficiency improvements, boiler efficiency provisions, compressed air system measures, as well as lighting and building envelope efficiency improvements. The industrial technical assistance program can identify opportunities for capture and use of process heat, as well as for implementation of combined heat and power. Opportunities for reducing the use of non-energy greenhouse gases can also be considered. Evaluation of the benefit to the individual plants visited of being served under alternative utility rate structures and assessments of load control opportunities can be included as well.
- The technical assistance programs can include follow-up mechanisms by which those who receive services are contacted at least twice after receiving the results to answer questions and give suggestions for installing the recommended measures, and to provide access to incentives (such as grants to cover a portion of the incremental cost of efficiency improvements) and financial assistance (such as low-interest loans) to encourage implementation of recommendations.

Initial goals for this option are to provide over 10,000 residential technical assistance visits, 1,500 commercial building technical assistance visits, and 300 industrial technical assistance visits annually once the technical assistance programs are fully implemented, and to have over 50% of consumers provided with assistance visits implement measures providing at least 50% of the GHG emission reduction potential of the recommendations. The CAPAG recommends that these goals be increased if needed, over time, to help to fully implement other RCI options.

Chapter 4
Energy Supply

Overview of GHG Emissions

Greenhouse gas (GHG) emissions from the energy supply (ES) sector in North Carolina include emissions from electricity generation and represent a substantial portion of the State's overall GHG emissions (approximately 46% of gross emissions in 2000). A significant portion of North Carolina's gross GHG emissions are associated with electricity imports - roughly 8% of the State's electricity-related fossil fuel emissions were associated with imports in 2000, though this is expected to decline to about 6% by 2020 based on the reference case forecast.

As shown on Figure 4-1, ES emissions are expected to increase from 1990 levels of 54 million metric tons (MMt) of carbon dioxide equivalent (CO_2e) to about 98 $MMtCO_2e$ by 2020, or by approximately 83% on a consumption basis. This projection assume that the gross electric generation trends shown in Figure 4-2 are not perturbed by GHG-reducing actions, such as implementation of some or all of the recommendations identified in this chapter.

Figure 4-1. Historical and projected GHG emissions from the Electric Sector, North Carolina, 1990 to 2020 (consumption basis)

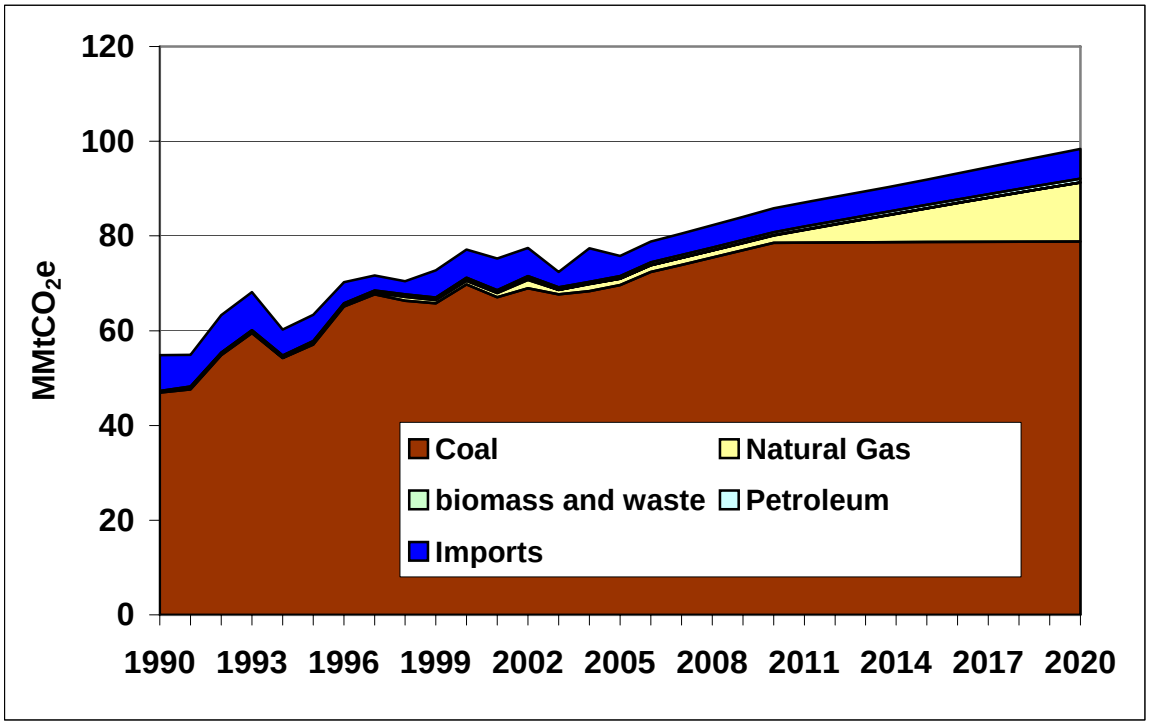
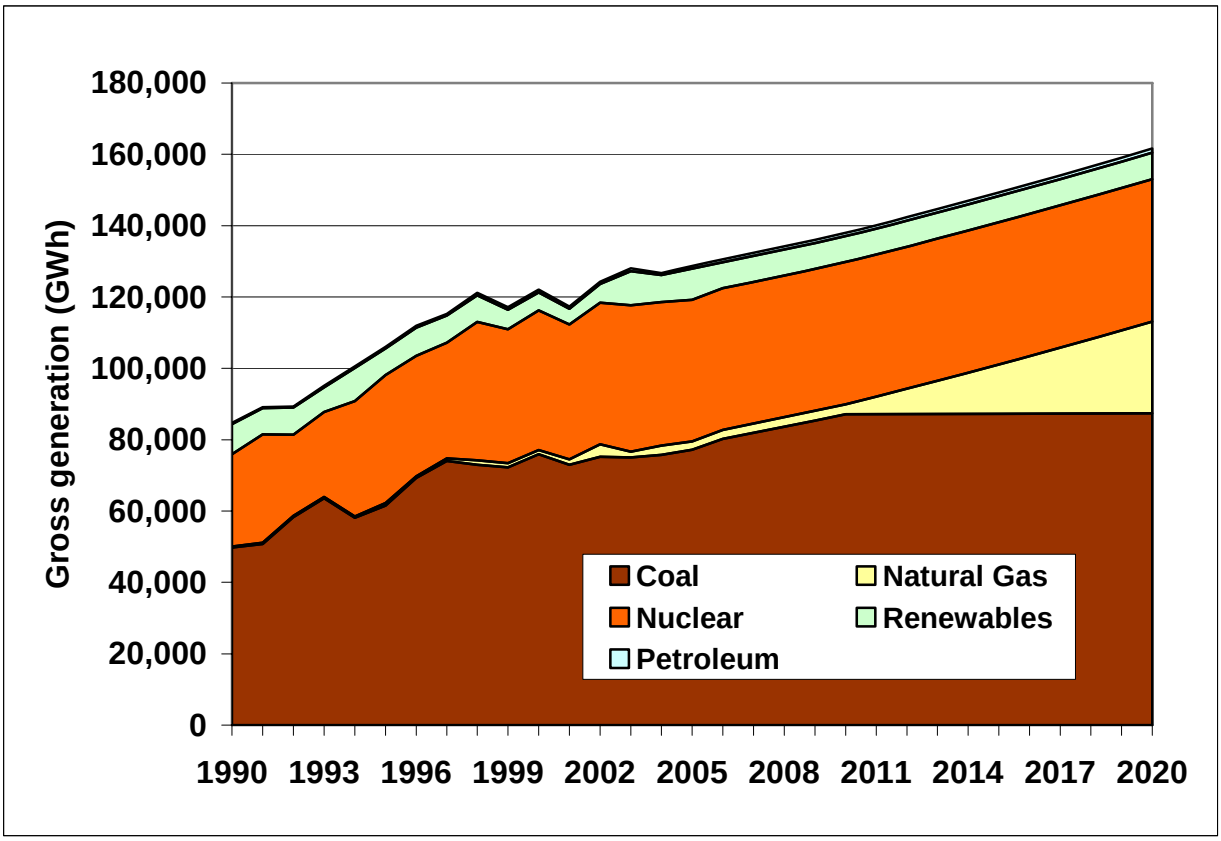


Figure 4-2. Historical and projected In-State Electric Gross Generation By Source,, 1990–2020



Note: only capacity additions assumed at the time of the analysis are included in the above generation projections..

Key Challenges and Opportunities

The key challenge in addressing GHG emissions from North Carolina's ES sector is the continued growth of electricity demand within the State. Electricity sales are projected to grow annually at the rate of about 1.6% between 2003 and 2020. This challenge is compounded by the fact that there is expected to be continued significant reliance on electricity produced by coal-fired power stations. These units produced 59% of all electrical energy generated in the state in 1990. While the share of coal-fired electricity is projected to decrease slowly, it is still projected to be a relatively high 54% by 2020.

Fortunately, there are significant opportunities in North Carolina to reduce the GHG emissions growth attributable to energy production and supply, including diminishing the carbon intensity of electrical generation through greater use of renewable energy options, and recapture of waste energy through combined heat and power and other technologies. Significant opportunities to reduce GHG emissions through mitigation options addressing electricity consumption also exist, and can often provide net cost savings to consumers and to the State. The CAPAG has identified several demand-side management, energy efficiency, and conservation measures in the Residential, Commercial, and Industrial Sector; these are detailed in Chapter 3.

North Carolina has significant renewable resources in the form of biomass, wind and hydro energy. North Carolina also has untapped onshore and offshore wind resources, albeit not necessarily well located to meet domestic demand. The intermittent nature of winds inhibits its value for providing baseload capacity, but its value to the electricity grid can be enhanced by carefully planning of wind facilities at multiple sites so they can support power demand in parts of the grid where it is most needed.

Overview of Mitigation Option Recommendations and Estimated Impacts

The CAPAG recommends a set of 9 mitigation options for the ES sector that offer the potential for significant GHG emission reductions. These recommendations include efforts to increase the supply of electricity from renewable energy sources (ES-1, ES-2, ES-8, and ES-10), encourage lower-emitting fossil fuel generation (ES-6), increase distributed generation and distributed combined heat and power (ES-3 and ES-9), implement cap in-state carbon emissions (ES-4), align environmental objectives within the planning process (ES-5), and reduce electricity demand (ES-7). It is important to note that all the options identified above were approved by unanimous consent of the CAPAG with the exception of the cap-and-trade option (ES-4) and the public benefits option (ES-7), both of which were nonetheless approved by a supermajority of the CAPAG.

A glance at the numbers in Table 4-1 would seem to suggest that if simply added together, the cumulative emission reductions of these mitigation options could exceed 800 $MMtCO_2e$ in 2020, and NPV costs could approach $4 billion, assuming all options are implemented in isolation from each other. These options are *not*, however, independently additive. In fact, they tend to overlap heavily, so simply summing them would introduce significant double-counting. These options essentially target – through different means – the avoidance of the same or similar emissions sources (e.g., the emissions from existing fossil-fuel power plants and those yet to be built). When taken together in a combined scenario that assumes all of the CAPAG's recommendations are fully implemented, these electricity supply recommendations are estimated to lead to cumulative GHG emissions reductions of about 78 $MMtCO_2e$ through 2020, at a NPV (net present value) cost of about $1.4 billion. (See Appendix F for discussion of the methodology used for the integrated analysis.)

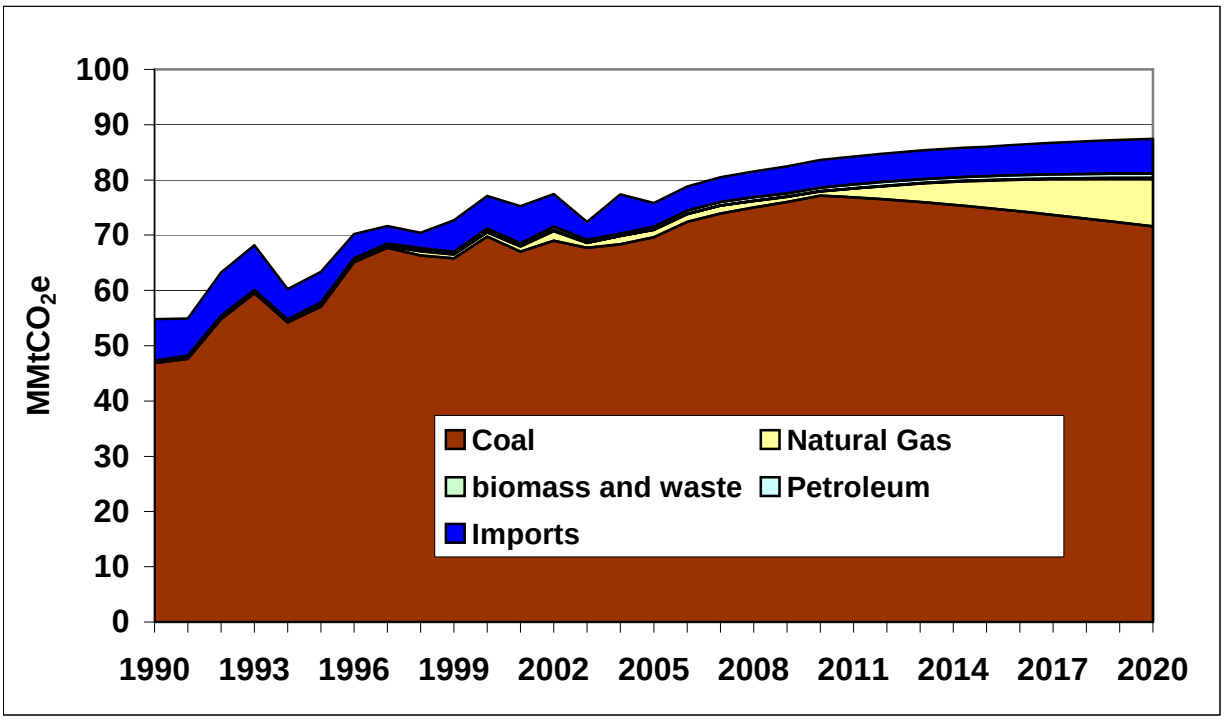
In fact, the CAPAG's recommendations concerning GHG emissions from electricity generation are also highly interactive with its RCI mitigation option recommendations concerning electricity use, because reducing electricity demand can offset the need for new generation, often at a lower cost or even with a savings. The scenario above (full implementation of all CAPAG recommendations) takes into account the many overlaps among ES and RCI mitigation options that reduce the demand for power.

The approach used for estimating emission reductions and costs associated with the combined set of ES and RCI mitigation options involved four major steps. First, electricity saving overlaps among RCI options was accounted for to eliminate the possibility of double-counting. Second, aggregate costs associated with the achieving total demand-side electricity savings were estimated. Third, revised electric generation requirements were estimated that accounted for

savings associated with energy efficiency options. Finally, a revised electric generation mix was determined that accounted for renewable energy and other ES options.

Overall, the combined ES and RCI recommendations yield potential reductions in electricity sector emissions from reference case projections of about 63 $MMtCO_2e$ per year by 2020 and cumulative reductions of 375 $MMtCO_2e$ from 2007 through 2020, at a net savings of approximately $6 million through the year 2020 on an NPV basis. These combined ES and RCI results are shown in Figures 4-3 and 4-4.[1]

Figure 4-3. Impact of electric supply options on electricity sector emissions (energy supply options only) mitigation case, 1990-2020

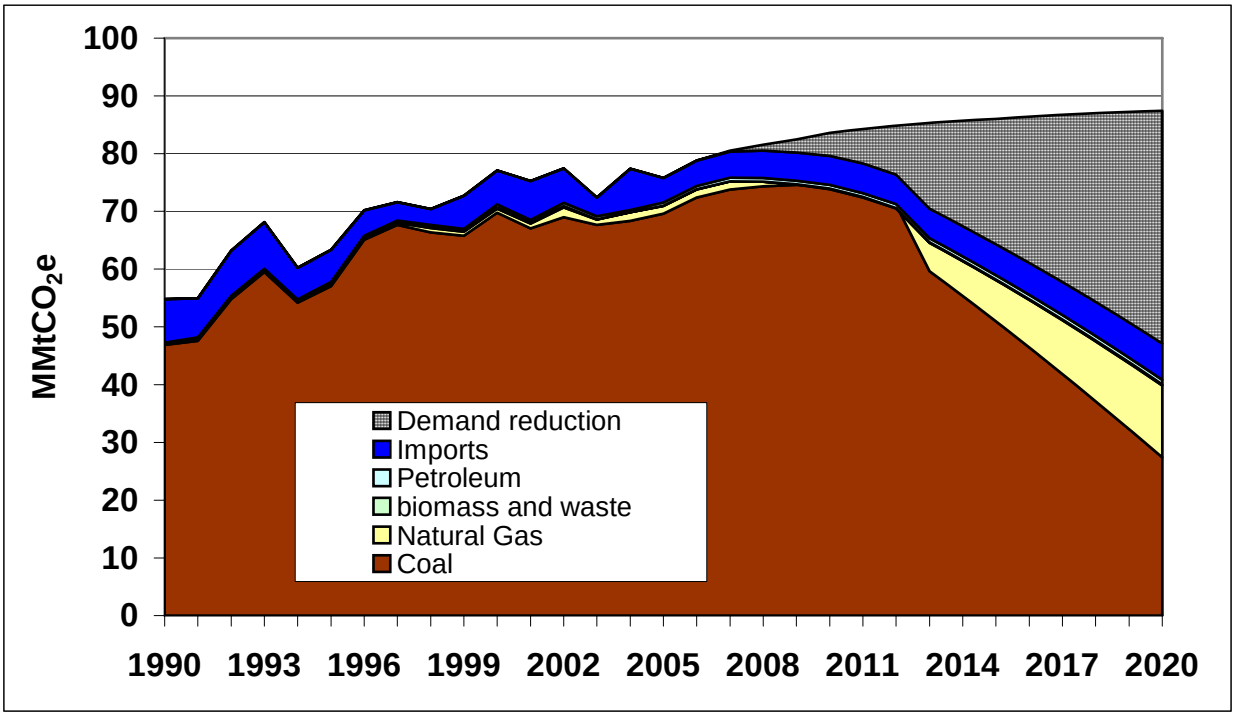


The estimated impacts of the recommended ES mitigation options are shown in Table 4-1. The CAPAG mitigation option recommendations described briefly here (and in more detail in Appendix F to this report) result not only in significant emissions savings, but offer significant additional benefits as well. A substantial expansion of renewable energy in North Carolina, for instance, may be accompanied by a corresponding increase in related jobs in North Carolina as energy investment shifts from fossil fuel production to the manufacture of renewable technologies. Portfolio diversification and hence energy security could be enhanced by the greater penetration of renewable energy resources into the energy marketplace. Moreover,

[1] The net cost savings are based on fuel expenditures, operations, maintenance, and administrative costs, and amortized, incremental equipment costs. All NPV analyses here use a 5% real discount rate.

energy reliability could be enhanced through the penetration of distributed generation.[2] Finally, air pollution-related public health and visibility impacts would decline with reduced fossil fuel-fired emissions from electricity generation. Nevertheless, some renewable sources (i.e., biomass) do emit small levels of GHGs.

Figure 4-4. Impact of supply- and demand-side mitigation option recommendations on electricity generation sector emissions (including demand reductions) mitigation case, 1990-2020



[2] See, for example, the study entitled, "The Role of Distributed Generation in Power Quality and Reliability" by Energy and Environmental Analysis, Inc prepared for NYSERDA in 2004 (available from http://www.eea-inc.com/natgas_reports/DGPowerQualityReport-NYSERDA.pdf).

Table 4-1. CAPAG-recommended mitigation options and results for the Energy Supply sector

	Mitigation Option Name	GHG Reductions ($MMtCO_2e$)			Net Present Value (Million $)	Cost-Effective-ness ($/$tCO_2e$)	Level of Support*
		2010	2020	Total 2007–2020			
ES-1	Renewable Energy Incentives	0.01	0.04	0.33	15	45.1	UC
ES-2	Environmental Portfolio Standard ***						
ES-2a	*Original analysis*	6.94	44.3	288.7	1,634	5.7	UC
ES-2b	*20% combined target*	5.90	23.4	166.2	409.80	2.5	UC
ES-2c	*Load growth offset target*	5.53	22.3	160.3	393.95	2.5	UC
ES-3	Removing Barriers to CHP and Clean DG	0.69	2.8	20.1	127.98	6.4	UC
ES-4	CO_2 tax and/or Cap-and-Trade						
ES-4a	Electric sector only	0.84	3.3	20.4	119	5.8	SMJ
ES-4b	Economy-wide	1.84	7.1	47.7	284	6.0	SMJ
ES-5	Legislative Changes to Address Environmental and Other factors	Not quantified					UC
ES-6	Incentives for advanced coal						
ES-6a	Replacement of new 800 MW pulverized coal plant	0.00	3.9	31.0	949	30.6	UC
ES-6b	Replacement of Existing 800 MW Pulverized Coal plant	0.00	5.4	42.9	2,061	48.1	UC
ES-7	Public Benefit Charge	0.8	3.4	24.4	329	13.5	SMJ
ES-8	Waste to Energy	0.0	0.0	0.02	–0.7	–36.8	UC
ES-9	Incentives for CHP and Clean DG	Combined with ES–3					UC
ES-10	NC GreenPower Renewable Resources Program	0.01	0.2	0.95	35	37.0	UC
	SECTOR TOTAL AFTER ADJUSTING FOR OVERLAPS**	6.5	62.7	375	–5.9	–0.016	
	REDUCTIONS FROM RECENT ACTIONS (none)	0	0	0	0	0	
	SECTOR TOTAL PLUS RECENT ACTIONS**	6.5	62.7	375	–5.9	–0.016	

* UC = unanimous consent (all agree), SMJ = super majority (at least 80 percent or more agree).

** For ES-2, ES-4, and ES-6, emission reductions and costs associated with ES-2b, ES-4a, and ES 6a were used in the cumulative analysis.

*** On August 20, 2007, toward the end of the CAPAG process, Governor Mike Easley signed into law S.L. 2007-397, which establishes a Renewable Energy and Energy Efficiency Portfolio Standard for the state.

Energy Supply Sector
Mitigation Option Descriptions

The ES sector includes emissions mitigation opportunities related to electricity generation. These options include mitigation activities associated with the generation, transmission, and distribution of electricity, whether generated through the combustion of fossil fuels or by renewable energy sources; in a centralized power station supplying the grid or by distributed generation facilities; or imported into the state.

ES-1. Renewable Energy Incentives (Biomass, Wind, Solar, Geothermal, Hydro)

This option focuses on financial incentives that promote the greater use of renewable energy. The incentives are focused primarily for residences, businesses, and other electricity end-users rather than for research and development, outreach, or inter-governmental programs. The effect of these incentives is to encourage investment in renewable power sources by providing direct financial support for adoption of these technologies.

ES-2. Environmental Portfolio Standard (Renewables and Energy Efficiency) with Renewable Energy Credit Trading

A renewable portfolio standard (RPS) is a mitigation option requiring investor-owned electric utilities to supply a certain percentage of retail electricity from renewable energy sources by a stipulated date. A type of RPS that includes measurable, verifiable and lasting efficiency options is an Environmental Portfolio Standard (EPS). Utilities can satisfy the renewable energy component of the EPS requirement by generating renewable energy themselves or by purchasing renewable energy credits (REC) from a renewable energy generator. A REC is equal to 1 kWh of eligible and verified renewable electricity produced

Three different targets were analyzed for the EPS, as briefly outlined in the bullets below:

- Aggressive target: this corresponds to a 31% combined energy efficiency and renewable energy target by 2020.
- 20% target: this corresponds to a 20% combined energy efficiency and renewable energy target by 2020.
- Load growth offset target: this corresponds to a combined energy efficiency and renewable energy target by 2020 that offsets load growth over that period.

ES-3 and ES-9. Removing Barriers and Providing Incentives to Combined Heat and Power (CHP) and Clean DG

Combined Heating Cooling and Power (CHP), also know as cogeneration, is a method of utilizing the thermal energy (heat) produced when generating electricity (power) in a single, coordinated process. CHP is more energy-efficient than separate generation of electricity at a

central electric plant and production of localized thermal energy for the end user. This distributed generation resource allows for recycling the heat, which is normally wasted to cooling towers or lakes at centralized electric generating stations, to meet onsite thermally-driven demand such as process and space heating, cooling, and dehumidification.

ES-4. CO_2 Tax and/or Cap-and-Trade (Covering Sources Including Fossil, Renewable, and Nuclear on Life Cycle Basis)

A cap and trade system is a market mechanism in which CO_2 and other GHG emissions are limited or capped at a specified level, and those participating in the system can trade permits (a permit is an allowance to emit one ton of CO_2 or its equivalent in other GHGs) in order to lower costs of compliance. For every ton of CO_2 (or other GHGs) released, an emitter must hold a permit. Therefore, the number of permits issued or allocated is, in effect, the cap on emissions. The government can give permits away for free (with permits distributed based on any one of many different criteria, to those participating in the cap and trade system or even to those who are not), auction them, or a combination of the two methods. Participants can range from a small group within a single sector to the entire economy, and can be implemented upstream (at the level of fuel extraction or import) or downstream at the points where fuel is consumed. The CAPAG considered two options for a cap-and-trade system in North Carolina: economywide and only on the power sector. Also, substantial discussion at the TWG and CAPAG levels focused on the geographic coverage of the system, with a number of members indicating that a national system is preferable to state or regional systems.

ES-5. Aligning Environmental and Profit Incentives Through Electric Sector Regulatory/Rate Reform

Several regulatory and rate reforms in North Carolina would encourage electric utilities to invest in clean, non-carbon-producing energy resources such as renewables and energy efficiency. Under the current rate structure, utilities have an incentive to invest in new large capital projects, which also may inhibit investments in energy efficiency. North Carolina could align the regulated electric utilities' profit motive with increased energy efficiency by removing perverse disincentives to energy efficiency. For example, a carbon adder on new supply sources would have the effect of favoring low carbon-emitting sources such as renewables and/or demand side energy efficiency over higher carbon-emitting sources such as IGCC, natural gas, and coal stations, in ascending order of the impact of a carbon adder.

ES-6. Incentives for Advanced Coal

Integrated gasification combined cycle (IGCC) is an emerging technology for coal-fired electricity generation, offering the potential for higher efficiency and reduced cost of pollutant emissions control. IGCC involves partially combusting coal under high pressure to produce a synthetic gas, which is then used in a combined-cycle combustion plant to generate electricity. IGCC can be combined with carbon capture and sequestration or reuse (CCSR) in North Carolina to lead to significant CO_2 emission reductions relative to those of conventional coal technology. Options for carbon storage are available though limited in the NC region. Based on

initial studies, potential sites are located offshore and just west of the state.[3] Support for RD&D for a range of other new technologies to further reduce GHG emissions from coal generation is also envisaged in this option.

ES-7. Public Benefits Charge on Electric Bills to Support Energy Efficiency Programs

A public benefits charge (sometimes called a systems benefits charge) is a non-bypassable fee attributed to electric customers based on their electricity use in a given time period. The funds collected are then provided to a third party to provide energy efficiency programming. The purpose behind public benefits charges is most often to reduce energy consumption. While efficiency improvements carry significant air quality and GHG benefits, this impact is rarely a consideration for creation of a program. In a GHG-constrained mitigation option context, these benefits boost the attractiveness of a public benefits charge option.

ES-8. Waste to Energy

The combustion of waste materials, or their conversion by biological or thermo-chemical means to an easily-used fuel, can be used to produce heating, cooling or electric generation with lower GHG emissions than many conventionally-fueled alternatives. This waste-to-energy mitigation option focuses exclusively on the use of methane derived from Municipal Sewage Treatment (MST) to produce electricity. This is due to the fact that the use of other waste resources to substitute for fossil fuels—including landfill gas (LFG), animal waste, agriculture waste, and forestry waste—are all covered under the Agriculture, Forestry, and Waste Management (AFW) TWG, and direct combustion of MSW is opposed by environmental interests.

ES-10. NC GreenPower Renewable Resources Program

NC GreenPower is an independent, nonprofit organization established to improve North Carolina's environment through voluntary consumer contributions toward the production of renewable energy. The goal of NC GreenPower is to supplement the state's existing power supply with more green energy—electricity generated from renewable resources like the sun, wind and organic matter. The program accepts financial contributions from North Carolina citizens and businesses to help offset the cost to produce green energy. NC GreenPower differs from a Renewable Portfolio Standard (RPS) in that the RPS requires that electric utilities provide a certain level of renewable energy capacity in their generation mix. NC GreenPower is entirely voluntary, with the revenue going toward paying incremental costs of renewable energy generation. Also, because all power purchased through NC GreenPower is produced inside the state, the program provides local and statewide economic development benefits.

[3] See "Potential Sinks for Geologic Storage of Carbon Dioxide Generated in the Carolinas", by Smith R., et al, prepared for the Southern States Energy Board, March 2007; available at http://www.beg.utexas.edu/environqlty/co2seq/pubs_presentations/CarolinasSummary_16April07.pdf.

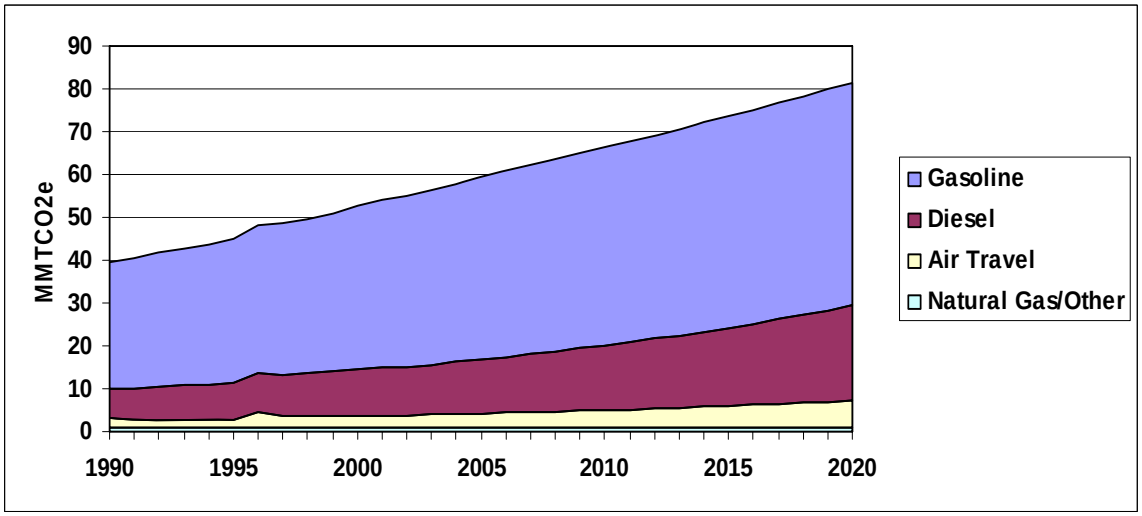
Chapter 5
Transportation and Land Use

Overview of GHG Emissions

The transportation sector is a major source of GHG emissions in North Carolina—currently accounting for 29% of the State's gross GHG emissions. Transportation emissions are determined by technologies, fuels, and activity rates. Activity rates, in turn, are determined in part by population, economic growth, and land use choices that affect the demand for transportation services. GHG emissions from the transportation sector totaled about 52.7 $MMtCO_2e$ in 2000.

Figure 5-1 shows historical and projected Transportation and Land Use (TLU) GHG emissions by fuel and source, and illustrates their rapid growth. TLU emissions are expected to more than double from 1990 from 2020. On-road vehicle miles traveled (VMT) are forecast to continue to grow faster than the population, and rapid growth in freight VMT is also expected. The high overall growth in transportation sector emissions suggests many opportunities and challenges for reducing North Carolina's GHG emissions.

Figure 5-1. Historical and projected GHG emissions from the Transportation and Land Use Sector, North Carolina, 1990 to 2020



Key Challenges and Opportunities

Options for reducing emissions from transportation fall into three categories:

1. Reducing GHG emissions per vehicle mile traveled,
2. Reducing the carbon intensity of fuels, and

3. Reducing activity rates, either absolutely or relative to the baseline. Policies may produce modal switches to lower-emission means of travel, and/or decrease the total amount of travel.

North Carolina has substantial opportunities to reduce emissions in each category:

- In North Carolina and in the nation as a whole, vehicle fuel efficiency has improved little since the late 1980s, yet many studies have documented the potential for substantial increases consistent with maintaining vehicle size and performance.
- The use of fuels with lower GHG emissions is growing and larger market penetration is possible.
- North Carolina also has taken steps to increase transit options and plan for growth that reduces emissions, but the state can absorb its rapid growth in development patterns that will produce far less travel, and far lower emissions than forecast.

Overview of Mitigation Recommendations and Estimated Impacts

The Climate Action Plan Advisory Group (CAPAG) recommends a set of 13 mitigation options for the Transportation and Land Use sector that offer the potential for major economic benefits and emissions savings. As summarized in Table 5-1, these mitigation recommendations come from each of the available reduction categories above, and could lead to emissions reductions from reference case projections of 25.5 $MMtCO_2e$ per year by 2020, cumulative savings of 232 $MMtCO_2e$ from 2008 through 2020, and net cost *savings* of over $4.3 billion to the North Carolina economy through the year 2020 on a net present value basis (NPV).[1] The weighted average cost of saved carbon from the mitigation options for which quantitative estimates of both costs and savings were prepared was –$19 per metric ton of CO_2 equivalent.

The estimated impacts of the individual mitigation options are shown in Table 5-1. The CAPAG mitigation recommendations described briefly here (and in more detail in Appendix G) result not only in significant emissions and costs savings, but offer a host of additional benefits as well. These benefits include (but are by no means limited to) reduced local air pollution, more livable, healthy communities, and increased transportation choices.

In order for the TLU mitigation options recommended by the CAPAG to yield the levels of savings described here, the options need to be implemented in a timely, aggressive, and thorough manner. To be most effective, the group of mitigation options aimed at VMT reductions and increased transportation choices (TLU-1a, Land Development Planning, and TLU-1b, Multi-Modal Transportation and Promotion) will require change at every level of government, and as such will be most effective with focused leadership by the State, including training, outreach, and technical assistance to local governments and businesses (either directly or via local governments). For example, TLU-1b, Multi-modal Transportation and Promotion, includes one of the empirically most powerful ways to reduce emissions, employer-based commute benefits. Among businesses that implement them, these are very popular and cost-effective. Yet for a

[1] The net cost savings are based on fuel expenditures, operations, maintenance, and administrative costs, and amortized, incremental equipment costs. All NPV analyses here use a 5% real discount rate.

variety of reasons, businesses implement these benefits at a much higher rate with government technical assistance.

Next, the State Clean Car program must clear several hurdles before North Carolina or any other state can adopt it, including EPA approval of the original California Clean Car Program (that other states can then opt into) and a court challenge to the underlying notion of regulation of GHG emissions from vehicles. If for any reason North Carolina is not able to implement the Clean Car Program, other options would need to play a larger role if the State is to meet its emissions reduction goals. For example, the mitigation options under the Rebates/Feebates Options Bundle (TLU-3b) could substantially improve fuel efficiency through market mechanisms and consumer labeling. Feebate proposals usually have two parts: (1) a fee on relatively high emissions vehicles; and (2) a rebate or tax credit on low emissions vehicles.

As a final example, Pay-As-You-Drive Insurance would require the State to not only allow insurance companies to offer customers a way to save each time a customer chooses to drive less, but also to promote that option, if the State is to see the levels of adoption analyzed here.

Most of the recommended mitigation options would produce substantial economic benefits for North Carolina. The sources, and calculations, of these benefits are detailed in Appendix G. Because the form of several of the recommendations leaves the State and its constituents substantial latitude in how to act to achieve the recommended goals, it was not possible to estimate financial costs and benefits for all options.

For example, TLU-1a recommends that the State's local jurisdictions develop growth plans. Given the substantial portion of forecast emissions growth driven by increasing driving, growing in more compact, mixed-use patterns is simply essential to meeting the State's emissions reduction targets. For the same reason, changing development patterns also offers the single largest potential emissions reduction from transportation. Each jurisdiction can develop its own approach to planning for growth, and because we cannot know which approach each will choose, we cannot estimate the cost for each, or, as a result, the likely total cost. In the case of TLU-1a, CCS reviewed experience in, and estimates for, growth planning in other states. With few exceptions, experience and forecasts across a wide variety of planning choices show *substantial* net cost savings from planned growth relative to the kind of growth now prevalent in North Carolina. North Carolina and its communities would likely save billions of dollars from shorter sewer lines, fewer needed new roads, and fewer new schools. But given the wide range of choices available to North Carolina communities under recommended TLU-1a, it is not possible to put a point estimate on the benefits that will likely be produced by those choices

The benefits from other recommended options were more straightforward to forecast. The technology required in TLU-5, tailpipe GHG standards for example, would more than pay for itself in reduced fuel consumption, while substantially reducing North Carolina's GHG emissions.

Cost Savings

Several of the TLU options (below) show higher estimated net savings than most other options both in and out of TLU. This subsection summarizes *briefly* the source of those estimates.

TLU-1b. Multi-Modal Transportation and Promotion

A wide variety of empirical experience suggests that the policies and investments listed in the Option Design and Implementation Mechanisms sections are likely to produce substantial net savings, as in the following four examples.

1. *Transit investments generally*

   Nationally, transit produces net economic returns on investment: "For every $10 million invested, over $15 million is saved in transportation costs to both highway and transit users. These costs include operating costs, fuel costs, and congestion costs."[2]

   At a high level, then, the benefits of the proposed investment in transit can be estimated as follows:

NC DOT budget:	$2.5 billion/year
13%	$325,000,000/year
× 1.5 savings multiplier	$487,500,000/year in savings
–cost of investment	$325,000,000/year
Total benefits	**$162,500,000/year**

   This substantial return on investment is the basis for the cost savings number reported in the summary table. Without knowing more about how North Carolina will make its transit investments, it is not possible to do a finer-grained analysis. However, *the following examples suggest that the 1.5x savings multiplier may be conservative*. [Portions of the following sections dealing with a possible savings multiplier are italicized.]

2. *Transit fare initiatives*

   Unlimited Access transit at the University of California-Los Angeles costs $810,000 a year, and has total benefits of $3,250,000 a year,[3] *a return on investment of more than 4x*. Similar programs at other universities show similar results.[4] The many educational institutions in North Carolina could see similar savings.

   Universities are in some senses unique institutions, but the general types of challenges (especially demand for, and costs of providing, parking), and the types of benefits enjoyed in response to commute benefits programs, are equally available to businesses. A report on this topic notes:

   > "Eco Passes also offer significant advantages for employers who offer free parking to all commuters, because those who shift from driving to transit will reduce the demand for employer-paid parking spaces. A survey of Silicon Valley commuters whose employers offer Eco Passes found that the solo-driver share fell from 76 percent before the passes were offered to 60 percent afterward. The transit mode share for commuting increased from 11 percent to 27 percent. These mode shifts reduced commuter parking demand by approximately 19 percent.

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[2] Cambridge Systematics, Inc., *Public Transportation and the Nation's Economy: A Quantitative Analysis of Public Transportation's Economic Impact,* 1999.

[3] Jeffrey Brown, Daniel Hess, and Donald Shoup, "Fare-Free Public Transit at Universities: An Evaluation," *Journal of Planning Education and Research* 23:69–82, 2003.

[4] Jeffrey Brown, Daniel Hess, and Donald Shoup, "Unlimited Access," *Transportation* 28:233–267, Kluwer, 2001.

"Given the high cost of constructing parking spaces in the Silicon Valley, *each $1 per year spent to buy Eco Passes can save between $23 and $333 on the capital cost* of required parking spaces."[5]

3. *Transit and non-SOV options information and promotion:* Per public dollar, a Transportation Management Organization (TMO) can *accommodate seven times as many commuters as new highway investment.*[6]

4. *TDM investments on the basis of avoided driving:* This policy is estimated to reduce VMT by 3,317,688,733 in 2012, and 3,970,779,011 in 2020. The current IRS-estimated cost of driving a mile in a personal vehicle is $0.485. At that rate, total savings will be

	2010	**2020** (constant $)
VMT reduced	$3,317,688,733	$3,970,779,011
@ $0.485 / VMT, Avoided costs =	$1.6 billion	$1.9 billion
–Cost of investment	$325,000,000	$325,000,000
Net savings	**$1.2 billion**	**$1.6 billion**

Thus, the estimated $162,500,000/year in total savings for this Option used for the summary table is very conservative.

TLU-3a. Surcharges to Raise Revenue

If, as in the above example, revenue is used to fund multi-modal options promotion that reduces VMT, then we can estimate net benefits as shown below:

	2010	**2020 (constant $)**
VMT reduced	$1,850,000,000	$1,850,000,000
@ $0.485 / VMT, Avoided costs =	$897,250,000	$897,250,000
–Cost of investment	$37,000,000	$37,000,000
Net savings	**$860,250,000**	**$860,250,000**

If, in an effort to be conservative, we limit the savings to the 7× savings multiplier found in a study for Minnesota DOT,[7] then the net benefits fall as follows:

	2010	**2020 (constant $)**
Cost of investment	$37,000,000	$37,000,000
Avoided cost @ 7x investment	$259,000,000	$259,000,000
Net savings	**$222,000,000**	**$222,000,000**

We use this lower number in Table 5-1.

[5] Ibid., p. 260.

[6] Minnesota Department of Transportation, Modal Options Identify Project, "Measurement and Evaluation," 2006.

[7] Ibid.

TLU-5. Tailpipe GHG Standards

A review of $/ton estimates prepared for the California Clean car-type regulation for California Air Resources Board (CARB), Northeast States for Coordinated Air Use Management (NESCAUM), and CCS produces an estimate of between $117 saved for each metric ton of CO_2e reduced at the high end, and roughly a third of that (~$38 saved for each ton) at the low end. We used the low end in an effort to be conservative. This figure takes into account not only the higher initial cost of the California Clean Car, but also the costs of financing that car. Both the higher costs and the savings from reduced fuel consumption would start immediately upon purchase, and CARB estimates that the net savings would begin immediately as well.

Table 5-1. CAPAG-recommended mitigation options and results for the Transportation and Land Use Sector

Option No.	Mitigation Option	GHG Reductions ($MMtCO_2e$)			Net Present Value 2008–2020 (Million $)	Cost-Effective-ness ($/$tCO_2e$)	Level of Support*
		2010	2020	Total 2008–2020			
TLU-1a	Land Development Planning	2.6	8.0	58.2	*Net savings*		SMJ
TLU-1b	Multi-Modal Transportation and Promotion (formerly TLU-2)	3.7	5.8	52.4	–1,300	–25	UC
TLU-3a	Surcharges to Raise Revenue	1.2	2.2	15.7	–1,800	–117	SMJ
TLU-3b	Rebates/ "Feebates" to Change Fleet Mix	0	<0.5	2.8	*Not quantified*	–40 to +10	SMJ
TLU-4	Truckstop Electrification	*Included in TLU-8*			*Net savings*		UC
TLU-5	Tailpipe GHG Standards	0	8.1	44.5	–1,690	–38	SMJ
TLU-6	Biofuels Bundle	1.9	4.5	35.4	*Not quantified*		UC
TLU-7	Procure Efficient Fleets	*Included in TLU-6*					UC
TLU-8	Idle Reduction/Elimination Policies	0.1	0.2	2.2	–6	–4	UC
TLU-9	Diesel Retrofits	0.3	2.2	13.5	*Not quantified*		UC
TLU-11	Pay-As-You Drive Insurance	2.3	5.3	42.0	*Expected net savings*		SMJ
TLU-12	Advanced Technology Incentives	*Not quantified*					UC
TLU-13	Buses – Clean Fuels	*Included in TLU-6*					UC
	SECTOR TOTAL AFTER ADJUSTING FOR OVERLAPS	11.1	25.5	232.3	–4,350	–19	
	REDUCTIONS FROM RECENT ACTIONS	0	0	0	0	0	
	SECTOR TOTAL PLUS RECENT POLICY ACTIONS	11.1	25.5	232.3	–4,350	–19	

* UC = unanimous consent (all agree); SMJ = super majority (at least 80% or more agree). TLU-2 was renamed TLU-1b because of its linkage to TLU-1a. There is no mitigation option TLU-10, because this catalog option was not advanced by the CAPAG.

Note that for TLU-5, the estimated emission reduction for each year from 2008 through 2020 was multiplied by the cost-effectiveness value of -$38/ton to estimate cost savings for each year, and then the cost savings for each year was discounted and summed to estimate the NPV. Thus, the cost-effectiveness value of –$38/ton cannot be replicated by dividing the cumulative cost savings by the cumulative emission reduction shown in this table.

Transportation and Land Use (TLU) Mitigation Option Descriptions

The Transportation and Land Use Sectors include emissions reduction opportunities related to reducing GHG emissions per miles of travel, reducing the carbon content of transportation fuels, and using transportation and land use policy to reduce the need to travel by high-emitting modes. Additional detail on each of the options summarized below can be found in Appendix G.

TLU-1a. Land Development Planning

The CAPAG recommends that North Carolina promote land planning and development that supports conservation of high quality natural and cultural resources and supports more compact development, and as a result reduces growth in driving and emissions. Do so by supporting and promoting private and public planning and development practices, including infrastructure provision, that reduce the number, length, or travel mode of trips made in North Carolina.

The suggested statewide goal is to reduce projected increase in VMT by 10% statewide by 2020. (Value was developed after review of targets in several other states, and an assessment by the group of the ability to meet the target.)

Meeting the goal will require diverse implementation tools. Providing many options, statutory changes, and program assistance for smaller communities will be essential.

Land Use and Development Legislation to Require Adoption of a Growth Plan

- *Each municipality and county shall develop a land use and development plan.*

  The plan should designate planned growth areas and natural resource areas within that jurisdiction and any extraterritorial jurisdiction for a planning horizon of at least 25 years. The land use and development plan should include standards and criteria for conservation area and/or urban service area designations to accommodate a minimum 20-year growth forecast agreed upon by the each county and municipality; establish development and conservation goals; recognize important natural and human resources; and, express appropriate policies, practices and strategies to implement these goals. Local planning programs should include appropriate public involvement processes to achieve consensus on the development and conservation vision for the community.

- *Require and support integration of transportation with land use plans.*

  Maryland, Minnesota, and Denver, CO, as well as the non-profit Triangle Land Conservancy have developed “greenprints” of areas that have old-growth forests, productive agricultural lands, water supply watersheds, historic sites or other critical and irreplaceable resources. Adding this as a required element of all transportation plans would be a simple and meaningful step that would greatly enhance the effect and benefits of NC GS 136-66.2 without requiring new zoning or regulatory powers. The November 2004 passage of tax increment financing legislation demonstrates that North Carolina can and does make room for new ideas that help achieve economic development goals in concert with infill

development objectives. The NC Small Town Economic Development (NCSTEP) initiative created grant funds that are being used in 33 communities to plan for growth and development in a way that will help those communities benefit from growth and minimize negative impacts.

Regulatory incentives such as withholding transportation funds for noncompliance have worked in Tennessee and should be considered in North Carolina as well.

TLU-1b. Multi-Modal Transportation and Promotion

The CAPAG recommends that the State work with its constituents to shift passenger transportation mode choice to lower emitting choices. Ensure that transportation is integrated with and appropriately serves land-use development plans (developed under TLU-1a). Implement the North Carolina transportation plan allocation of 13% of state transportation spending to transit.

Implement policies that increase use of public transportation, producing a shift to lower emitting mode choices, by the following policies:

- Improve Transit Service (frequency, convenience, quality).
- Expand Transit Infrastructure (rail, bus, Bus Rapid Transit).
- Focus new development on transit-served corridors (Transit-Oriented Development).
- Expand Transit Marketing and Promotion (including tax-free and employer-paid Commuter Benefits, and Parking Cash Out).
- Expand Transportation System Management and Design, which speeds both transit and other traffic.
- Improve bike and pedestrian infrastructure both as feeders and as stand-alone modes.
- Many programs are in place and are therefore immediately expandable/implementable. Enhancement and continuation can begin short-term. These implementation mechanisms include
    - Aggressively support and aid the creation of Regional Transportation Districts (RTDs). RTDs can sell bonds for capital projects, and member governments can levy taxes for operation and maintenance subject to voter approval.
    - Make planning and funding rules more flexible to allow transit operators to provide service to places outside of their municipal jurisdictions.
    - Abolish or reduce minimum parking requirements in zoning codes, and allow localities to establish parking maximums.
    - Create a best practice guide and recognize developers who adhere to best practice when designing and locating new private and public development.
    - Require planning to extend beyond 5 years (20 years recommended) for all systems.
    - Create incentives or require the purchase of biodiesel fuel (minimum: B20) as a part of all public bus replacement programs. Conover has already done so with great results.

- Location of State Facilities—Locate state facilities near transit facilities. Where and when appropriate/possible all state government offices should be located downtown. Similarly, provide transit to serve concentrations of state employees.[8]
- State Targeting of Infrastructure Investments—Legislatively appropriated capital outlay funds, state public revolving loan fund, and other state-funded infrastructure initiatives should be used for projects that encourage walkable and traditional communities, and are supportive of transit.
- Make maintenance of infrastructure a priority—Fix it First. Revise any state infrastructure programs; transportation, water, sewer, that fund new systems but not maintenance or upgrades for existing systems.
- Replace "average cost pricing" for utilities services with rate structures that charge full marginal costs for both new infrastructure and for water, sewer, electricity, and telephone service delivery.
- Fund the transportation-related programs in this mitigation option with monies generated by other mitigation options such as feebates and/or gas tax.

TLU-3a. Surcharges to Raise Revenue

The CAPAG recommends that the State vary motor vehicle registration fees by vehicle emissions to provide a surcharge on higher emitting vehicles.

This surcharge would raise funds for State of North Carolina to support transportation-related projects that reduce GHG. It would raise these funds through a mechanism that is directly tied to a significant source of GHG emissions from cars and trucks. It is not envisioned that the scale of the surcharge would affect the fleet mix; the goal of this policy is revenue-raising that is tied to emissions.

- 5.1 million North Carolina LDV registrations per year at an average of $7.25 per vehicle would produce $37 million per year for programs to reduce emissions from travel.
- The most efficient regionally funded regional commuter programs can reduce VMT for a cost of 2 cents/mile. Most regional commuter programs cost more per mile. On the other hand, few are as well funded as this proposal, and there are almost certainly economies of scale and scope.
- $37 million per year times $0.02 per mile equals 1,850,000,000 VMT = 2% of total statewide VMT; 3% of total urban LDV VMT.

TLU–3b. Rebates/Feebates to Change Fleet Mix

The CAPAG recommends that the State charge a sliding scale of fees and rebates for new light-duty vehicles based on their emissions of greenhouse gases and/or other measures of a vehicle's

[8] This is an Executive Order from North Carolina Governor James Holshouser.

environmental impacts. This will provide an incentive for manufacturers to sell cost-effective efficiency technologies, and for consumers to buy lower-emitting vehicles by

- Having price signals reflect emissions levels and thus have emissions levels more directly enter buying decisions, and
- Sending a signal to manufacturers to produce increasingly low-emitting vehicles for the market.

The revenue should be used to create a dedicated revenue stream for promotion of low emitting or no emitting GHG transportation alternatives (e.g., hybrid tax credits, transit infrastructure). In addition,

- Emissions could be considered relative to other vehicles within each class or across classes based on their design variations.
- The rebate/feebate could be set as a multiplier for an excise tax so that the fee or rebate is determined not only by the emissions rate of the vehicle but by its price as well.
- Generally the rebate/feebate design needs to be simple, minimize the number of pivot points, be well-documented, and be designed to maximize consumer attention.

A wide variety of economics literature finds that vehicle buyers do not buy all the efficiency technology that is cost-effective, taking into account the net present value of both the fuel savings and the additional technology cost. Feebate analyses find that the fuel savings that result from a feebate program would pay for additional costs, producing net cost savings:

> "The reduction in consumer surplus is more than compensated for by unvalued fuel savings that are realized. The benefits are positive for all rates up to $1000 but marginal costs begin to outweigh benefits between $500 and $1000. Adopting two or more classes reduces the benefits significantly while creating a relative subsidy for larger vehicles."

As a result: Net benefits range from $40 per ton for a low feebate, to $10 per ton for a high feebate.

TLU-4. Truck Stop (and Places Where Trucks Stop) Electrification

The CAPAG recommends that North Carolina reduce idling-induced emissions from heavy-duty diesel trucks by providing—or helping the market to provide—electrical hook-ups to power heating, cooling, and other needs while stopped.

North Carolina should analyze existing pilot projects at major truck stops on interstate highways (principally, I-40 and I-85) and initiate other efforts at other places where truck traffic is high; then, progress to include all major truck stops statewide with at least one multi-unit electrified stop in each of the 17 urban areas in North Carolina.

North Carolina has several TSE pilots in place. While programs are in discussion there are no policies or laws to enforce participation.

TLU-5. Tailpipe GHG Standards

The CAPAG recommends that North Carolina join with the 13 other states that have adopted the State Clean Car Program to reduce emissions of GHGs from vehicle operation.[9]

TLU-5 would use California Clean Car standards for cars and light trucks to reduce GHG emissions. California standards require GHG emissions reductions of about 30 % from new vehicles, phased in from 2009 to 2016, through a variety of means.[10] Other Clean Car Program elements include standards requiring reductions in smog- and soot-forming pollutants, and promoting introduction of very low-emitting technologies into new vehicles.

The General Assembly could enact legislation in 2009, at the earliest, unless tied to a 2007 bill carried over to 2008 so that North Carolina can implement the California standards.[11]

TLU-6. Biofuels Bundle

The CAPAG recommends that the State work to increase market penetration of biofuels in North Carolina by a mixture of policies (voluntary and/or mandatory) to achieve feasible goals—offsetting fossil fuel use (gasoline) with production and use of starch-based and cellulosic ethanol.

Replacing gasoline with ethanol can reduce GHG's to the extent that the ethanol is produced with lower GHG content. Biodiesel has a lower GHG content than fossil diesel, so using biodiesel instead of fossil diesel reduces GHG emissions.

This option is linked with policy options AFW-2, Biodiesel Production, and AFW-6, Policies to Promote Ethanol Production. This option seeks to develop the demand for biofuels, whether produced locally or out-of-state. (Options AFW-2 and AFW-6 pursue the GHG benefits achievable beyond TLU options by promoting in-state production of ethanol and biodiesel using feedstocks and production methods with greater GHG benefits than the likely business-as-usual national market production methods, e.g., conventional starch-based ethanol.)

The goals for this policy should be phased in utilizing biofuels to replace the specified percentages of gasoline and diesel consumed for transportation throughout North Carolina by the specified years, as shown Table 5-2, below. The goals of this policy can be achieved through a combination of a renewable fuels standards, financial incentives, outreach, and market-based mechanisms.

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[9] Also known as the "Pavley" standards (after Assemblywoman Fran Pavley who introduced the legislation) or "California GHG emission standards."

[10] For detailed information, see: http://www.arb.ca.gov/cc/ccms/ccms.htm

[11] The California standards currently are being litigated, and timing may be affected as a result. Recent court decisions have found that CO_2 can be a pollutant under the Clean Air Act (CAA). Many observers see this as clearing the way for the required EPA waiver under the CAA.

Table 5-2. Goal levels and timing for biofuels implementation

Phase	Year	Percentage of Gasoline to be Replaced by Biofuels	Percentage of Diesel to be Replaced by Biofuels
1	2010	10% (E10 equivalent)	5% (B5 equivalent)
2	2015	15% (E15 equivalent)	10% (B10 equivalent)
3	2020	20% (E20 equivalent)	15% (B15 equivalent)
4	2025	25% (E25 equivalent)	20% (B20 equivalent)

The CAPAG recommends pursuing these goals through the following mechanisms:

- Pursue DOE and State funding for more alternative fuel pumps throughout the State and for introducing appropriate infrastructure throughout the State. Some federal tax incentives currently exist for the purchase of alternative fuel vehicles. When the federal incentives expire, examine the feasibility/need to continue such incentives for alternative fuel vehicles.
- Reduce or eliminate the motor fuels tax on biodiesel and ethanol (E85). Develop a system to provide for monthly credit for biodiesel and E85 blended fuel that would be equivalent to the state motor fuels tax owed on the biofuels portion of the fuel blend. (This could follow in the wake of elimination of tax on "home brew" biodiesel by 2007 legislature.)

  Monthly tax credits would be claimed on the same form (Biodiesel and Fuel Alcohol Providers Form) marketers currently file with the North Carolina Department of Revenue (DOR) Motor Fuel Tax Division to pay fuel tax. This would reduce pump price of Biofuels as marketers would pass most of the credit on to consumers to be competitive. Credits could be paid out of General State Revenues, DOT highway funds. Credit would be revenue neutral as it would be equal to the tax that would have been paid by marketers for biofuel portion of blend.

- Develop a $0.25/gallon credit for biodiesel and ethanol use in North Carolina vehicles.

  As above, the tax credit would be claimed on the DOR Biodiesel and Fuel Alcohol Providers Form. Similarly, this would reduce price of Biofuels as marketers pass the credit on to consumers in order to be competitive. General State Revenues, or DOT highway funds could pay for the credit. Unlike above, this credit would not be revenue neutral as the state would be providing incentive for fuel sold to non-taxable entities (local and state government) as well as sales to taxable entities. However, only the biofuel portion of blended fuel would be eligible for 25-cent credit. For example a B20 blend would get a 5-cent credit.

- Create a tax credit for biodiesel producers.
- Develop a mandated Renewable Fuel Standard (RFS), corresponding to the penetration rates listed above.

  The RFS should include a cost trigger, so that if the cost of alternative fuels exceeds conventional fuels by more than a specified amount, the RFS would be temporarily removed. The cost trigger should be based on costs over a period of time, and not spot prices. Additionally, production issues should be included in the trigger, such as water use in growing corn (or other crops) for the biofuels, such that the production of the biofuels does not increase GHG emissions or cause other resource problems.

TLU-7. Procure Efficient Fleets

The CAPAG recommends that the State reduce GHGs by increasing the efficiency of vehicle fleets generally, beginning with government lead by example. Also increase fleet use of alternative fuels.

- Increase government fleet use of low-GHG fuels and more efficient vehicles to reduce greenhouse gas emissions from fleets. In addition to CO_2 reductions, this would reduce emissions affecting ozone, sulfur, and carbon monoxide loadings.
- Set statewide GHG reduction targets for fleets phased in over period of probably 8-10 years to allow fleet turnover to absorb most of the costs of replacing existing fleets. Other measures regarding more frequent maintenance and part specifications could be phased in much faster.

TLU-8. Idle Reduction/Elimination Policies

The CAPAG recommends that the State implement state policies, and support the development of local policies, to reduce hours of operation and thus emissions from idling trucks and buses (principally), perhaps off-road engines as well.

These would reduce greenhouse gas emissions from heavy vehicles and reinforce Truck Stop Electrification (TSE).

This would require working with trucking groups, truck stops, and places where trucks stop as well as with government to formulate an agreeable policy approach, phasing schedule, and legislative content.

About 15 states and a number of local governments have adopted anti- idling legislation.[12] More are sure to follow or are already being discussed at some level. Toronto has had a law in place since 1996. Many North Carolina counties and the State Board of Education (Policy No. EEO-M-003) have adopted school bus idling policies already.[13] The Clean School Bus USA program (USEPA) should also be consulted.[14]

TLU-9. Diesel Retrofits/Retirement

The CAPAG recommends that the State reduce diesel emissions from older diesel engine/emission systems through a broad retrofit and/or retirement program. Create incentives and encourage retrofits through a combination of funding and education/promotion.

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[12] See http://atri-online.org/research/idling/Cab%20Card%20July%202006.pdf

[13] See http://www.ncbussafety.org/idling.html

[14] See http://www.epa.gov/cleanschoolbus/

This policy would reduce children's exposure to diesel emissions by retrofitting school buses in North Carolina with diesel oxidation catalyst (DOC) control devices, and/or diesel particulate filters, which have the auxiliary benefit of reducing some GHGs and carbon black.

Beyond school buses, the CAPAG recommends that the state speed retirement and/or retrofit of all older diesels through information and incentives.

- **Utilize various funding mechanisms** to purchase DOC pollution control devices and/or particulate traps for school buses that are not equipped with pollution control devices.
- **Provide information and education:** An information and education component is needed to provide truck and bus owners, school districts, and municipal organizations with information regarding the significant emissions reductions that could be achieved by retrofitting or retiring certain truck or bus engines with high annual emissions and replacing them with vehicles meeting the new emissions standards. Provide information on potential funding partners, grants, or loans available from a number of organizations for this purpose.
- **Develop funding mechanisms or incentives:** Develop a loan or grant program allowing truck owners to accelerate new vehicle purchases or to apply retrofit technologies to their fleets.

Currently in North Carolina, there is an ongoing effort to retrofit school buses across the State with diesel pollution control devices. An estimated 15% of the school buses in the State are already equipped with some type of pollution control device. Sources of funding include Federal and State grants, local funding and gifts from private industry. The primary purpose of these diesel pollution control devices is to reduce particulate matter.

Legislation currently under consideration, HB 1912: School Bus Retrofits in Nonattainment Areas, addresses school bus retrofits.

TLU-11. Pay-As-You-Drive Insurance

The CAPAG recommends that the State use Pay-As-You-Drive (PAYD) insurance pricing to convert a portion of insurance to a variable cost with respect to vehicle travel, so premiums are directly related to mileage. PAYD makes insurance more actuarially accurate and allows motorists to save money when they reduce their mileage. The less you drive the more you save.

Proposal would require insurance companies to offer PAYD as part of their menu of insurance choices in North Carolina. A pilot project could be implemented first on a small scale as soon as possible. Option design is to have full North Carolina light-duty fleet PAYD coverage by 2020.

TLU-12. Advanced Technology Incentives

Technology will play a vital role in dramatically reducing carbon emissions from the cars of the future. Fuel cells, plug-in hybrid, low weight carbon-fiber bodies, and other technologies will require research, development, and commercialization. The CAPAG recommends that because of its strong research university and both its high-tech and auto parts manufacturing, that North

Carolina (especially through the Department of Commerce) encourage advanced automobile technology research and recruit the new generation of manufacturers.

Studies can evaluate if there is an economic opportunity around the development and commercialization of advanced technology vehicles and suggest possible models for the Department of Commerce to take advantage of such opportunities.

The following are goals of this policy:

- Enable North Carolina's economy to establish itself in the research, development, and commercialization of advanced automotive technologies.
- Grow North Carolina's capacity to recruit sustainable industry.

TLU-13. Buses – Clean Fuels

The CAPAG recommends that TLU-7 (Procure Efficient Fleets) also include transit bus fleets.

Chapter 6
Agriculture, Forestry, and Waste Management

Overview of GHG Emissions

The agriculture, forestry, and waste management (AFW) sectors are directly responsible for a small amount of North Carolina's current greenhouse gas (GHG) emissions. For agriculture, net emissions were 11.0 million metric tons (MMt) of carbon dioxide equivalent (CO_2e) in 2000. Agricultural emissions include methane (CH_4) and nitrous oxide (N_2O) emissions from the digestive systems of livestock (enteric fermentation), manure management, agriculture soils, and agriculture residue burning. As shown in Figure 6-1, emissions from agricultural soils and manure management in cattle account for the largest portions of agricultural emissions. The agricultural soils category includes N_2O emissions resulting from activities that increase nitrogen in the soil, including fertilizer (synthetic, organic, and livestock) application and production of nitrogen-fixing crops. Agricultural residue burning emissions are too small to show up in Figure 6-1.

Note that, in keeping with United States Environmental Protection Agency (US EPA) methods and international reporting conventions, the inventory and forecast covers human-caused (anthropogenic) sources of GHGs. There could be some natural sources of GHGs that are not represented in the inventory and forecast; however, these are not addressed in the Climate Action Plan Advisory Group (CAPAG) process. In the forestry sector, all emissions are treated as anthropogenic, since all of the State's forests are managed in some way (GHG reporting conventions are to treat all managed forests as anthropogenic sources). Sources such as carbon dioxide from forest fires and decomposing biomass are captured within the inventory and forecast (as part of the carbon stock modeling performed by the U.S. Forest Service [USFS]). However, methane emissions from anaerobic decomposition of biomass in forests are not currently captured due to a lack of data.

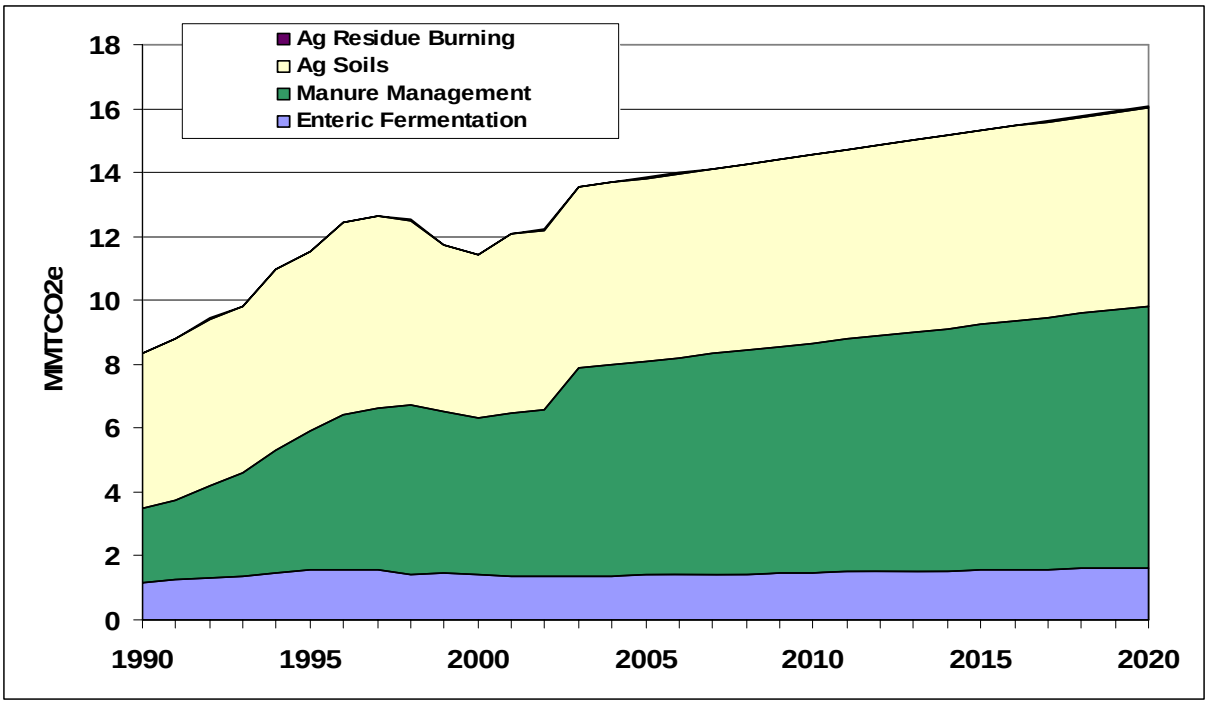
The contributions from agricultural soils and manure management have grown significantly since 1990, and they are projected to contribute 90% of agricultural emissions by 2020. Emissions from enteric fermentation have stayed the same since 1990 and are projected to stay relatively constant until 2020. GHG emissions from agricultural burning are estimated to continue to contribute a very small amount to the agricultural sector emissions.

Forestland emissions refer to the net carbon dioxide flux[1] from forested lands in North Carolina, which account for about 56% of the state's land area. As shown in Table 6-1, USFS data suggest that North Carolina forests captured and stored (sequestered) an average of 23.7 $MMtCO_2e$ per year from 1987 to 1997. The CO_2 is sequestered in forest carbon pools such as live trees, debris on the forest floor, and forest soils, as well as in harvested wood products (e.g., furniture and lumber) and the landfilling of forest products. The data show an accumulation of carbon in each

[1] "Flux" refers to both emissions of CO_2 to the atmosphere and removal (sinks) of CO_2 from the atmosphere.

of the forest carbon pools during this period.[2] These rates of sequestration are assumed to remain constant through 2020.

Figure 6-1. Historical and projected GHG emissions from the agriculture sector, North Carolina, 1990–2020



Enteric Fermentation = production of methane and from the digestive systems of livestock.

Table 6-1. GHG emissions (sinks) from the forestry Sector

Forest Carbon Pool	1990–2020* MMtCO_2e
Live and dead-standing trees and understory	–6.9
Forest floor and coarse woody debris	–0.8
Soils	–3.1
Harvested wood products and landfills	–13
Total	–23.7

* Based on USFS data from 1983 to 1997.

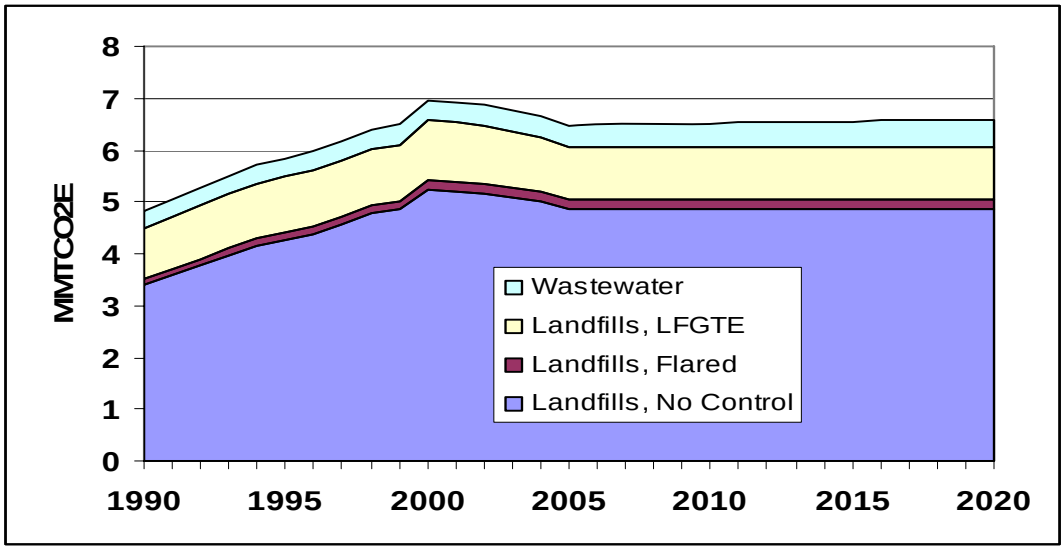
Figure 6-2 shows estimated historical and projected emissions from the management and treatment of solid wastes and wastewater. Emissions from waste management consist largely of CH_4 emitted from landfills, while emissions from wastewater treatment include both CH_4 and N_2O. Landfill emissions are broken down into three subsectors: uncontrolled landfills (no CH_4 collection or control), flared landfills (CH_4 collected and flared), and landfill-gas-to-energy

[2] This is not to say that the dead carbon pools (e.g., standing dead, forest floor) are sequestering carbon directly from the atmosphere. These pools accumulate carbon from trees/biomass that transition from a live carbon pool to a dead carbon pool.

(LFGTE) landfills (CH_4 collected and used as an energy source). Overall, the waste management sector accounts for less than 4% of North Carolina's total gross emissions per year from 1990 through 2020.

Opportunities for GHG mitigation in the AFW sector involve measures that can reduce emissions within the sector or reduce emissions in other sectors. For example, production of liquid biomass fuels can offset emissions in the transportation sector, while biomass energy can reduce emissions in the energy supply (ES) or residential, commercial, and industrial (RCI) sectors. Similarly, actions that promote solid waste recycling can reduce emissions within the sector (future landfill CH_4) as well as emissions associated with the production of recycled products (recycled products often require less energy to produce than similar products from raw materials).

Figure 6-2. Estimated historical and projected emissions from waste and wastewater management in North Carolina



The following are primary opportunities for GHG mitigation.

- *Control and utilization of CH_4* —Methane emissions from manure management can be reduced through the use of anaerobic digesters or other technology. Methane can also be collected from landfills. The CH_4 captured can then be used to create electricity, steam, or heat to offset fossil fuel use.
- *Protection of forest and agricultural land from conversion to developed use*—By protecting these areas from development, the carbon in aboveground biomass and belowground soil organic carbon can be maintained, and additional emissions of CO_2e to the atmosphere can be avoided. Indirectly, these measures also support the objectives of "smart" development by helping to direct more efficient development patterns (see TLU-1a).
- *Beneficial use of forest and agricultural biomass*—Expanded use of biomass energy from residue removed from forested areas during treatments to reduce fire risk, crop residues, or

purpose-grown crops can achieve GHG benefits by offsetting fossil fuel consumption (to produce either electricity or heat/steam).

- *Production of renewable fuels*—Production of renewable fuels, such as ethanol from crops, crop residue, forestry residue, or municipal solid waste, and biodiesel from crop seed oils can produce significant reductions when they are used to offset consumption of fossil fuels (e.g., gasoline and diesel in the transportation and land use (TLU) and RCI sectors). This is particularly true when these fuels are produced using processes and/or feedstocks that emit much lower GHG emissions than those from conventional sources.
- *Enhancement of forest carbon sinks*—Through programs that restore forests on lands that are currently not forested or under-stocked, additional CO_2 can be sequestered and stored in forest biomass. Similarly, in urban settings, expansion and maintenance of urban forests can increase sequestration and reduce energy consumption in buildings through shading and wind protection.
- *Retention of agricultural soil carbon*— Implement programs that incentivize growers to utilize cultivation practices that build soil carbon. By building soil carbon, CO_2 is sequestered from the atmosphere. Some cultivation practices also require the use of lower amounts of fossil fuels which further lowers GHG emissions.
- *Expansion of recycling infrastructure*—Increase the quantity of materials recovered for recycling with specific attention given to materials with the greatest ability to reduce energy consumption during the manufacturing process and to materials that may be used as a fuel source.

Key Challenges and Opportunities

In the agricultural sector, options to promote biodiesel and ethanol production were found to offer substantial GHG reduction potential with an estimated reduction of 7.7 $MMtCO_2e$ by 2020 (combined benefit of Options AFW-2 and AFW-6). This is the benefit from in-state production using North Carolina–grown feedstocks and/or lower GHG production methods. The benefit is incremental to the benefit achieved via the renewable fuels standards incorporated in TLU-6. The benefits for both biodiesel and ethanol are based on production methods and feedstocks that have lower GHG emissions than conventional processes. For ethanol, this means processes that achieve much better GHG reductions than the production from conventional starch-based ethanol (the benefits of using ethanol from starch-based production are already accounted for under TLU-6). These processes could include cellulosic hydrolysis, biomass gasification combined with biofuels production, or alternative starch-based production methods (fermentation processes fueled by renewable fuels). Feedstocks for the fiber needed by this mitigation option could come from crop residue, forestry biomass, animal waste, and municipal solid waste. A major challenge for the success of AFW-6 is the production of a viable commercial-scale cellulosic ethanol industry by 2015.

For biodiesel, crop production should be promoted that results in significantly better vegetable oil yields than soybean oil, which is currently the most prominent feedstock in the United States. Candidates include vegetable oil crops like canola, sunflower, or jatropha that have much higher yields or emerging technologies like algal oil production.

The challenges for biofuels in North Carolina will be to identify and promote appropriate feedstocks for the production of these fuels. Limited analysis by the CAPAG suggests that sufficient feedstock for cellulosic ethanol is available to meet the mitigation option's objectives. There is limited capacity within the state for crop production to support all of the biodiesel production envisioned by the CAPAG's recommendation without the use of cropland that is currently used for other purposes. Hence, careful study is needed to identify available croplands and appropriate crops for seed oil production. Funding and/or incentives will be needed to support the development of alternative biofuels production capacity, including research and development on emerging feedstocks and scale-up of production facilities. The biofuels recommendations assume commercial-scale viability of new technologies (e.g., cellulosic ethanol, algal biodiesel) within the policy period; however, these assumptions are consistent with the timing horizons provided by industry and government experts.

As shown in the mitigation option descriptions in Appendix H, the implementation mechanisms developed for the agricultural sector should focus on methods that avoid conflict with potential future market-based GHG reduction programs. These include GHG credits that could be generated in the agricultural sector through renewable fuels projects, soil carbon projects, and possibly other project types. New regulations that mandate emission reductions or specific agricultural practices could limit North Carolina agriculture from taking part in emerging carbon markets. Implementation mechanisms that are incentive and education based can avoid these conflicts.

Combining the agricultural and forestry land preservation options (AFW-4a and AFW-4b), 4.6 $MMtCO_2e$/year in GHG emissions is estimated to be saved in 2020. To achieve these reductions, the state will need to work closely with local planning agencies, landowners, and nongovernmental organizations to identify lands suitable for acquisition/conservation easements and funding mechanisms. Another benefit to these options, which was not quantified, is the reduction in vehicle miles traveled due to more efficient development patterns (see TLU-1a).

Agricultural Biomass Feedstocks for Electricity or Steam Production (AFW-5) recognizes the need for incentives to build a biomass feedstocks collection and distribution infrastructure within the state. While the estimated emission reductions shown in Table 6-2 appear very small, these reductions account for the GHG reductions associated only with collection and transportation of locally derived biomass fuel compared with sourcing fossil fuel from out-of-state sources (assumed to be Pennsylvania coal). The GHG reductions that occur as a result of combusting biomass versus fossil fuels are captured in the energy supply and RCI sector policy recommendations for renewable energy.

Within the forestry sector, tree planting (afforestation and creating new forests) on non-forested lands (AFW-8) has the potential to deliver an additional 2.4 $MMtCO_2e$/year in 2020. The mitigation option aims at afforestation of lands that are primarily agricultural today. Hence, a key uncertainty in the implementation of this option is whether or not landowners will be willing to accept a new form of land management that has an investment structure different from that of agriculture (e.g., different from the Conservation Reserve Program under the U.S. Farm Bill).

Table 6-2. CAPAG-recommended mitigation options and results for the agriculture, forestry, and waste management sector

Option No.	Mitigation Option Name	GHG Reductions ($MMtCO_2e$)			Net Present Value 2007–2020 (Million $)	Cost-Effective-ness ($/$tCO_2e$)	Level of Support*
		2010	2020	Total 2007–2020			
AFW-1	Manure Digesters & Energy Utilization	0.2	0.9	6.4	199	31	UC
AFW-2	Biodiesel Production (Incentives for Feedstocks and Production Plants)	0.2	0.8	5.1	286	56	UC
AFW-3	Soil Carbon Management (Including Organic Production Methods Incentives)	0.2	0.2	3.0	–16	–5	UC
AFW-4a	Preservation of Working Land – Agricultural Land	0.2	0.3	2.6	290	114	UC
AFW-4b	Preservation of Working Land – Forest Land (Formerly AFW-7)	1.7	4.3	36	112	3	UC
AFW-5	Agricultural Biomass Feedstocks for Electricity or Steam Production	0.009	0.02	0.2	10	54	UC
AFW-6	Policies To Promote Ethanol Production	0.9	6.9	38	200	5	UC
AFW-7	*Moved To AFW 4a*						
AFW-8	Afforestation and/or Restoration of Non-Forested Lands	0.2	2.4	15	128	9	UC
AFW-9&10	Expanded Use of Forest Biomass and Better Forest Management	1.5	5.9	48	–639	–13	UC
AFW-11	Landfill Methane and Biogas Energy Programs	1.1	2.9	20	23	1	UC
AFW-12	Increased Recycling Infrastructure and Collection	0.2	0.5	4.1	52	13	UC
AFW-13	Urban Forestry Measures	1.4	4.3	34	–376	–11	UC
	SECTOR TOTAL AFTER ADJUSTING FOR OVERLAPS	7.8	29	212	270	1	
	REDUCTIONS FROM RECENT ACTIONS (none)	0	0	0	0	0	
	SECTOR TOTAL PLUS RECENT ACTIONS	7.8	29	212	270	1	

$MMtCO_2e$ = million metric tons of carbon dioxide equivalent; UC = unanimous consent (all agree).

Expanded Use of Forest Biomass and Better Forest Management (AFW-9&10) are estimated to deliver 5.9 $MMtCO_2e$/year in GHG emissions savings in 2020. The emission savings are offered through additional carbon sequestration in forest ecosystems and durable wood products and through fossil fuel offsets from forest-based energy (GHG benefits of fossil fuel offsets are accounted for in AFW-6 and in the RCI and ES sectors). Success will be achieved through close cooperation between North Carolina, federal agencies (such as USFS), and private industry to identify biomass resources and effective end uses for the resources. Key uncertainties include (1) the unknown willingness of many landowners to increase levels of forest management even with increased incentives and (2) uncertainty in future timber markets.

Also in the forestry sector, AFW-13 (Urban Forestry Measures) has significant potential for GHG benefits (4.3 $MMtCO_2e$/year by 2020). This is a combination of direct benefits (CO_2 sequestration in urban trees) and indirect benefits (lower energy consumption in buildings through shading and wind protection) with the indirect benefits yielding most of the benefit. The biggest challenge confronting the success of this mitigation option is in containing the costs associated with tree planting and maintenance programs. For example, the costs of tree planting programs can vary substantially, depending on whether the labor is paid or unpaid. Hence, strong relationships between all of the related parties are needed (State Department of Forestry, utilities, communities, nongovernment organizations). Also, the ability to implement these programs in smaller and newer communities on previously cleared land may be limited by the administrative capacity of these communities.

Landfill Methane and Biogas Energy Programs (AFW-11) offers the potential for emission savings directly by controlling landfill CH_4 emissions and indirectly through offsetting fossil fuel use (2.9 $MMtCO_2e$/year by 2020). An additional benefit of this option includes reducing landfill gas emissions of volatile organic compounds, including some that are hazardous air pollutants. Challenges of this mitigation option include the location of landfills in very rural areas resulting in a lack of viable local end users for the gas; the possible treatment as a regulated utility can also prevent landfill-gas-to-energy projects from being developed.

Through implementation of AFW-12, additional GHG reductions can be achieved by increasing waste recycling programs in the state (0.5 $MMtCO_2e$/year). Through recycling, emissions are reduced by avoiding future landfill CH_4 and by lower energy consumption in the production of recycled products versus products made from raw materials. Emission reductions were estimated to cost \$13/tCO_2e through developing additional recycling infrastructure.

Overview of Mitigation Option Recommendations and Estimated Impacts

The CAPAG recommends a set of 12 mitigation options for the AFW sector that offer the potential for major emissions savings. As summarized in Table 6-2, the AFW mitigation option recommendations could lead to emissions reductions from reference case projections of 29 $MMtCO_2e$/year by 2020, cumulative reductions of around 213 $MMtCO_2e$ from 2007 through 2020, and a net cost of approximately \$270 million through the year 2020 on a net present value (NPV) basis.[3] The weighted average cost of saved carbon is estimated at \$1/tCO_2e. The CAPAG believes that this represents an extremely low cost to the North Carolina economy in implementing this package of options.

The CAPAG mitigation option recommendations described briefly here (and in more detail in Appendix H) result not only in significant emissions savings but also offer a host of additional benefits. These benefits include but are not limited to (1) support of North Carolina agricultural producers in the production of biofuels crops, development of new markets for agricultural by-products, and training/outreach covering energy production, organic farming, and other areas; (2) creation of jobs in the biomass energy and liquid biofuels feedstock and production

[3] The net cost savings are based on fuel expenditures, operations, maintenance, and administrative costs, and amortized, incremental equipment costs. All NPV analyses here use a 5% real discount rate.

industries; (3) healthier forests with lower fire risk by developing markets for forestry residue; and (4) research and development work to be conducted by North Carolina universities and other in-state organizations to support many of the options for this sector.

Among the important assumptions that have been made to support the development of the estimated benefits and costs are the commercial-scale viability of advanced biofuels feedstock sources and production methods. Additional uncertainties exist in these estimates that could benefit from additional detailed study, including the costs associated with biomass collection and transport and electricity transmission infrastructure needs (costs for grid connection to utilize electricity from renewable sources).

Agriculture, Forestry, and Waste Management Sector Mitigation Option Descriptions

The agriculture, forestry, and waste management sectors include emissions and mitigation opportunities related to the use of biomass energy, protection and enhancement of forest and agricultural carbon sinks, control of agricultural CH_4 emissions, production of renewable fuels, use of methods to increase soil carbon, achievement of afforestation on non-forested lands, and an increase in recycling.

AFW-1. Manure Digesters and Energy Utilization

The CH_4 emissions inherent from the anaerobic (without oxygen) decomposition process of manure and other wastes may be captured and used as an energy source. By doing this, it is possible to both reduce CH_4 emissions and offset fossil-based energy. However, the cost of emission captures and energy production can be higher than the value of the energy collected, making this option cost prohibitive for producers operating in a tight-margin business. This option covers programs to increase the number of CH_4 capture and energy recovery projects using manure or other wastes (including food processor wastes). This is increasingly done in "anaerobic digesters"—containers in which organic wastes break down releasing CH_4. The goal is to capture 20% of available CH_4 from confined animal operations by 2020 for use in energy projects. The mitigation option is designed to apply to hog farms and dairies in the state.

AFW-2. Biodiesel Production (Incentives for Feedstocks and Production Plants)

Use of biodiesel offsets the consumption of diesel fuel produced from oil (fossil diesel). Since biodiesel has a lower GHG content than fossil diesel, overall GHG emissions are reduced. By producing biodiesel in the state for consumption within the state, the highest benefits can be achieved, since the fuel is transported over shorter distances to the end user. This option covers incentives needed to increase biodiesel production to offset 12.5% of North Carolina's fossil diesel consumption by 2020.

Note: This option is linked with Transportation and Land Use Option 6 (TLU-6) on Biofuels. AFW-2 seeks to achieve incremental GHG benefits beyond the TLU option by promoting in-state production of biodiesel using feedstocks with greater GHG benefits than the likely business-as-usual national production methods. In addition, North Carolina consumption of biodiesel produced in-state will produce better GHG benefits than biodiesel obtained from a national market because of the lower embedded CO_2 associated with transportation of biodiesel or its feedstocks from distant sources.

AFW-3. Soil Carbon Management (Including Organic Production Methods Incentives

Use of conservation tillage, no-till methods, cover cropping, and other soil management practices can increase the level of organic carbon in the soil, which stores/sequesters CO_2. In addition,

some practices lower fossil fuel consumption through less intensive equipment use. Other practices, such as the application of bio-char (charcoal or bio-mass–derived black carbon), can also increase the level of soil carbon and improve the soil.

Another element of this option is the promotion of certified organic production techniques. A number of studies have found that organic production of row crops results in GHG benefits, including levels of soil organic carbon higher than those from conventional production methods. This option is designed to increase the acreage using soil management and production practices that lead to higher soil carbon content and other GHG benefits. Specific goals include applying soil management practices on 20% of acres that currently do not use these practices by 2010 and increasing that amount to 50% by 2020.

AFW-4a. Preservation of Working Lands – Agricultural Land

This mitigation option seeks to reduce the rate at which existing crop and pasture lands are converted to developed uses. The carbon sequestered in soils and aboveground biomass is much higher in croplands than in developed lands. Policies are needed to preserve working farms and forests (see AFW-4b) from unwise and unplanned development. This option should be seen as a companion measure to TLU-1a (Land Development Planning).

State and national programs have been established to protect farm communities from conversion to development. Funding state farmland preservation programs will help meet goals and act as a needed match to national programs. Programs that help farmers transition lands to new/ beginning farmers are being investigated. The goal is to reduce the rate at which agricultural lands are converted to developed use by 50% by 2020 from current levels.

AFW-4b. Preservation of Working Lands – Forest Land

North Carolina has lost, on average, 61,390 acres of productive forest each year over the last 30 years to development and to a lack of post-harvest regeneration. This amounts to a loss of about 10% of the state's forestland since 1974, or an annually compounded loss of about 0.36%. The goal of this option is to reduce the rate of conversion of forestlands to non-forest lands by 10% by 2010 and 25% by 2020. When converted to developed areas, these areas contain lower amounts of biomass and its associated carbon. These areas also sequester less CO_2 than forested areas. When landowners don't have the incentive to retain their ownership, they often sell not only for development but they also sell for a forested tract as smaller parcels which may then be too small to allow forest management to be practical. On tracts too small and fragmented to be managed, the goals of AFW 9&10 cannot be achieved.

AFW-5. Agricultural Biomass Feedstocks for Electricity or Steam Production

This mitigation option seeks to offset fossil fuel use with agricultural biomass as feedstocks for electricity, steam, or heat generation. Agricultural biomass includes, but is not limited to, poultry litter, livestock manure, and crop residues, as well as energy crops (e.g., switchgrass and hybrid poplar). Offsetting fossil fuel use reduces the GHG emissions associated with these fuels. The

goals are to increase agricultural biomass usage to utilize 10% of available biomass by 2010, 25% of available biomass by 2020, and 50% of available biomass by 2030. Voluntary, incentive-based programs should be used to foster development of the industry and associated economic markets.

Note: This option links with AFW-1, which promotes the use of anaerobic digesters and energy utilization. It explores additional opportunities for agricultural biomass energy use. This option also has linkages to ES-1 (Renewable Energy Incentives), ES-2 (Environmental Portfolio Standard), ES-10 (NC GreenPower Renewable Resources Program), and RCI-10 (Distributed Renewable and Clean Fossil Fuel Power Generation).

AFW-6. Policies to Promote Ethanol Production

Offset fossil fuel use (gasoline) with production and use of starch-based (e.g., corn) and cellulosic (plant fiber) ethanol. Offsetting gasoline use with ethanol can reduce GHGs to the extent that the ethanol is produced with lower GHG content. Provide incentives for the production of ethanol from crops, forest sources, animal waste, and municipal solid waste. Several projects are being proposed that would result in the production of 150 million gallons of ethanol annually in North Carolina by 2008. Incentives could increase this amount to a volume equivalent to offsetting gasoline consumption in the state by 10% in 2015 and 25% by 2025. These goals are based on cellulosic ethanol being commercially viable by 2015.

Note: This option is linked to TLU-6, biofuels option, which focuses on mechanisms to increase biofuels consumption in North Carolina. The quantification of benefits and costs for each option takes into account the anticipated GHG reductions to be achieved by each.

AFW-8. Afforestation and/or Restoration of Non-Forested Lands

Afforestation, the planting of trees on lands that have not recently supported forests, has both carbon sequestration and other environmental benefits—storing more than one ton of carbon per acre each year (on-site, not including off-site storage and offsets in products). Afforestation delivers other important benefits such as improved wildlife habitat, reduced soil erosion and fertilizer runoff, and new recreational opportunities. Existing afforestation programs are underfunded for the task of this afforestation; typically, there is a long waiting list for landowner forestation projects. This option covers the provision of additional incentives to increase the rate of afforestation and restoration (e.g., increased stocking on poorly managed stands). The goals are to achieve afforestation projects on 40,000 acres of land by 2010 and a total of 540,000 acres by 2020.

AFW-9&10. Expanded Use of Forest Biomass and Better Forest Management

This mitigation option seeks to expand the production and use of wood products for solid wood products, fiber, and fuel. Such use offsets fossil fuel burning in the production of substitute materials (e.g., cement or steel for solid wood products and plastic for wood fiber). Wood can be substituted for fossil fuels directly in the case of biomass for energy. However, these GHG

benefits are not explicitly included in the analysis, which focuses on direct carbon sequestration in forests and in wood products. Having a market for relatively low-value biomass products enables forest management for higher value solid wood products. The increase in growth and yield of production from sustainably managed forest resources can be done through site preparation, competition control, thinning, fertilization, and improved genetics. The goal is to increase forest productivity by 100% on half of North Carolina timberlands by 2020.

AFW-11. Landfill Methane and Biogas Energy Programs

Provide incentives that will result in an increase in the recovery of landfill CH_4 for use as an energy source. Increasing recovery of landfill CH_4 reduces emissions of GHG and offsets the use of fossil fuels for commercial and industrial heat/steam generation or electricity production. Of approximately 130 open and closed landfills in the state, only about 15 sites are currently recovering landfill CH_4 for energy use. The aim of this mitigation option is to increase the number of uncontrolled municipal solid waste landfills recovering CH_4 as an energy source, such that 50% of the landfill gas being generated is controlled by 2020. This can be done through the development of additional LFGTE projects. For sites where LFGTE is not feasible, the aim is to implement flaring controls—burning the methane on-site to reduce GHG emissions.

Note: This option has linkages to ES-1 (Renewable Energy Incentives), ES-2 (Environmental Portfolio Standard), ES-10 (NC GreenPower Renewable Resources Program), and RCI-10 (Distributed Renewable and Clean Fossil Fuel Power Generation).

AFW-12. Increased Recycling Infrastructure and Collection

Increase the quantity of materials recovered for recycling with specific attention given to materials with the greatest ability to reduce energy consumption during the manufacturing process and to materials that may be used as a fuel source (e.g., clean wood waste). Reducing the quantity of materials being put in landfills reduces the potential for future landfill CH_4 emissions, while recycling reduces emissions associated with the manufacturing of products from raw materials. The aim of this mitigation option is to increase per capita recovery in the state by 25% by 2020.

AFW-13. Urban Forestry Measures

Urban forest cover protection and management offers a potentially cost-effective mechanism to reduce energy use, to store/sequester carbon, and to mitigate land use change (conversion of forest and agricultural lands to residential sites). Strategic planting of trees to shade houses and air conditioning units can yield energy savings of 15% to 50% on cooling costs. Planting shade trees can reduce summer cooling costs, with only marginal increases in winter heating costs, particularly in mild climates. In addition, depending on local conditions, tree planting can reduce wind speed and further reduce energy costs. The net direct impacts of tree planting are estimated to be positive, taking these factors into account.

Specifically, this mitigation option aims to increase urban tree cover by planting three additional trees (i.e., three more than planned) on all new construction sites starting in 2008 and by planting three new trees on 25% of existing housing units in 2007 by 2020, with the aim of achieving a 25% reduction in annual heating and cooling costs.

Chapter 7
Cross-Cutting Issues

Overview of Cross-Cutting Issues

Some issues relating to climate policy cut across multiple or all sectors. The Climate Action Plan Advisory Group (CAPAG) addressed such issues explicitly in a separate Technical Work Group (TWG) as "cross-cutting" issues rather than assigning them to any individual sector. The Cross-Cutting Issues (CC) TWG developed recommendations for each of six mitigation options (see Table 7-1) that were then reviewed, revised, and ultimately adopted by CAPAG as recommendations to North Carolina (NC) Department of Environment and Natural Resources (DENR). These issues include establishing an ongoing function with the State of North Carolina to assess and forecast greenhouse gas (GHG) emissions, the reporting of GHG emissions by entities, the registering of any GHG reductions achieved by entities for possible future credit and/or recognition, a variety of public education and outreach initiatives regarding climate change, and recommendations for a voluntary goal to reduce statewide GHG emissions. In addition, the CAPAG adopted a recommendation to create a state-sanctioned Blue Ribbon Commission on Adaptation to Climate Change to develop a comprehensive state Climate Change Adaptation Plan identifying opportunities to address adaptation issues and risks.

Table 7-1. CAPAG-recommended mitigation options and results for Cross-Cutting Issues

Option No.	Mitigation Option Name	GHG Reductions ($MMtCO_2e$)			Net Present Value 2007–2020 (Million $)	Cost-Effective-ness ($/$tCO_2e$)	Level of Support*
		2012	2020	Total 2007–2020			
	Cross-Cutting Issues						
CC-1	GHG Inventories and Forecasts	*Non quantified*					UC
CC-2	State Greenhouse Gas Reporting	*Non quantified*					UC
CC-3	State Greenhouse Gas Registry	*Non quantified*					UC
CC-4	State Climate Public Education and Outreach	*Non quantified*					UC
CC-5	State Climate Change Adaptation Strategy	*Non quantified*					UC
CC-6	Options for Goals or Targets (for CAPAG in Support of LCGCC	*Non quantified*					UC

* UC = unanimous consent (all agree); CAPAG = Climate Action Plan Advisory Group; LCGCC = [North Carolina] Legislative Commission on Global Climate Change.

Key Challenges and Opportunities

Establishing a GHG inventory and forecasting function within state government will assist in tracking, managing, and ultimately reducing GHG emissions. Establishing this function at the Division of Air Quality (DAQ) offers significant opportunities for the state to systematically and efficiently integrate this function with the DAQ's expertise and its ongoing program to develop

inventories and forecasts for the criteria air pollutants. It will also enable multi-pollutant assessments of air emissions programs within the state since criteria air pollutant and GHG emissions will be based on the same emission source activity data.

The GHG reporting and registry programs present special challenges and opportunities. Any regional or national effort involves reconciling the interests and perspectives of different states. The states are at much different stages of the learning curve with respect to these and other climate actions. After the CAPAG completed its recommendations on these mitigation options, North Carolina joined *The Climate Registry* as a step toward developing a nationally uniform GHG reporting and registry capability for North Carolina sources.[1] Being a charter state in this effort creates a unique opportunity for North Carolina to help ensure that North Carolina's needs and priorities are addressed in the course of *The Climate Registry*'s development. To the extent that North Carolina's needs may not be fully met by *The Climate Registry*, the state should consider developing supplemental or ancillary registry capacity or opportunity.

Public education and outreach programs can be difficult to develop and measure, but successful climate action will ultimately hinge on the public's awareness of climate risks and solutions. Public education and outreach efforts should integrate with and build upon existing outreach efforts involving climate change and related issues in the state. Ultimately, public education and outreach will be the foundation for the long-term success of all the mitigation actions proposed by the CAPAG as well as those that may evolve in the future. Key challenges may be associated with coordinating existing efforts by state agencies and securing long-term funding to support these programs. However, these challenges also offer opportunities for improving the effectiveness of education and outreach efforts over the long term.

The CAPAG recommends that the state set a voluntary GHG reduction goal but that the adoption of such a goal should first be considered by the NC Legislative Commission on Global Climate Change (LCGCC). If recommended by the LCGCC, such a goal could be established by the General Assembly or by an executive order of the Governor. By setting and adhering to a GHG reduction goal, North Carolina will join many other states across the country that are demonstrating leadership in reducing their own GHG emissions. It will also provide an incentive for North Carolina citizens, businesses, and state and local governments to seek out economic opportunities to reduce GHG emissions and to position North Carolina as a supplier of carbon credits to developing carbon markets while simultaneously reducing energy costs.

Due to the existing buildup in the atmosphere of GHGs that has already occurred, North Carolina will experience some effects of climate change for years to come, even if immediate action is taken to reduce future GHG emissions. Recognizing this concern, the CAPAG agreed unanimously that it is essential for the state to initiate efforts to identify potential short-term, mid-term, and long-term impacts of climate change scenarios likely to affect the state and develop a framework for prioritizing and responding to the potential impacts identified. Thus, the

[1] The Climate Registry (http://www.theclimateregistry.org/) is a collaboration between states, provinces and tribes aimed at developing and managing a common GHG emissions reporting system with high integrity that is capable of supporting various GHG emission reporting and reduction policies for its member states and tribes and reporting entities. It will provide an accurate, complete, consistent, transparent and verified set of GHG emissions data from reporting entities, supported by a robust accounting and verification infrastructure. As of July 2007, 39 U.S. states, several Tribal Authorities, two Canadian Provinces, and one Mexico state have joined *The Climate Registry*.

CAPAG recommends that the state empanel a Blue Ribbon Commission on Adaptation to Climate Change to develop a state Climate Change Adaptation Plan within one year of establishment of the Commission. The Commission should involve and coordinate with all appropriate state and local agencies, organizations, and institutions (e.g., universities) to ensure that all potential impacts are identified in the plan. This recommendation offers challenges in that legislative approval for funding will be required to support the Commission and development of the plan. However, developing a sound, coordinated planning effort to address North Carolina's vulnerabilities to climate change is likely to pay for itself many times over, will help establish priorities, and will help identify opportunities for mitigating health and economic impacts associated with climate change in the state.

Overview of Mitigation Option Recommendations

Cross-cutting issues include options that apply across the board to all sectors and activities. Cross-cutting recommendations typically encourage, enable, or otherwise support emissions mitigation activities and/or other climate actions. The CAPAG recommends that six such options be adopted and implemented by the State. All six are enabling options that are not quantified in terms of tons of reductions or costs/cost savings. Detailed descriptions of the individual Cross-Cutting Issues mitigation options as presented to and approved by the CAPAG can be found in Appendix I. Annex A to Appendix I offers additional reference materials that the CAPAG used in developing its recommendations for the inventories and forecast, reporting, registry, education and outreach, and adaptation mitigation options.

Cross-Cutting Issues
Mitigation Option Descriptions

CC-1 GHG Inventories and Forecasts

GHG emissions inventories and forecasts are essential to understanding the magnitude of all emission sources and sinks (both natural and those resulting from human activities), the relative contribution of various types of emission sources and sinks to total emissions, and the factors that affect trends over time. The Center for Climate Strategies (CCS) is providing a baseline inventory as a part of this project. It should be a platform for further updating and improvement. The initial use for inventories and forecasts will be to inform state leaders and the public on statewide trends, opportunities for mitigating emissions or enhancing sinks, and verifying GHG reductions associated with implementation of North Carolina's Climate Action Plan. However, it is expected that other uses of the data will be identified as the program evolves.

The CAPAG recommends that the responsibility for preparing GHG inventories and sinks should reside with the DAQ, which has the expertise needed to systematically compile information on GHG sources and sinks using established methods and data sources. Other state agencies as well as private facilities (sources) will need to provide data to DAQ on a periodic basis. This program should be integrated with existing DAQ inventory and forecast functions as seamlessly as possible as committed to by DAQ in the September 2005 Report under the Clean Smokestacks Act. This inventory and forecast function should be implemented as soon as possible to establish an ongoing effort that will be improved over time based on improvements to the accuracy and completeness of data needed to support this effort.

The CAPAG recommends that the state develop a periodic, consistent, and complete inventory of all emission sources and sinks (both natural and those resulting from human activities) on a continuing basis with forecasts to reasonable and realistic future years (5 and 10 years), to and including 2020 (and eventually beyond), as allowed by funding. The process for these and other sources should repeat as often as necessary to track significant reductions or increases, beginning with every year for major point sources and every third year for other sources to be in agreement with routine US EPA (United States Environmental Protection Agency) air emissions reporting requirements and regulations for other regulated air pollutants. The inventory should include all natural and man-made emissions generated within the boundaries of the state (i.e., production-based inventory approach) as well as emissions associated with energy imported and consumed in the state (i.e., consumption-based inventory approach). The state should provide a projection of the emissions from the same source categories and on the same basis into the future for a realistic forecast of what the emissions will be in future years reflecting expected growth and application of scheduled and expected mitigation options. The state should also provide a basis for documenting emission reductions and credits "by difference" from year to year.

CC-2 State Greenhouse Gas Reporting

GHG reporting reflects the measurement and reporting of GHG emissions at a statewide, sector, or sub-sector level to support tracking and management of emissions. GHG reporting can help sources identify emission reduction opportunities and reduce risks associated with possible future GHG mandates by moving up the learning curve. Tracking and reporting of GHG emissions would also help in the construction of periodic state GHG inventories. GHG reporting is typically a precursor for sources to participate in GHG reduction programs, provide opportunities for recognition, create a GHG emission reduction registry, and secure "baseline protection." Further, collaboration with other states in the development of a GHG reporting program could enable North Carolina to influence the development of GHG reporting practices throughout the region and nation and build consistency and reciprocity with other state or regional GHG reporting programs.

Accordingly, the CAPAG recommends that North Carolina develop and implement a voluntary GHG reporting program as soon as possible. Reporting should occur annually on a calendar-year basis for all six traditional GHGs and, to the extent possible, for black carbon. In order to encourage GHG mitigation activities from all quarters, all entities that can verify ownership of GHG emissions should be encouraged to participate in a reporting program. Every effort should be made to maximize consistency with federal, regional, and other states' GHG reporting programs and quantification protocols in order to maximize consistency and reciprocity with federal, regional, and other states' GHG reporting programs. The reporting of GHGs would help position sources for participating in an emissions trading program, should one develop in the future, leading to cost savings.

For entities participating in a reporting program, reporting of direct emissions should be required, reporting of emissions associated with purchased power and heat should be phased in, and reporting of other indirect emissions should be allowed. Reporting of GHG emissions should be on an organization-wide basis within North Carolina, but with greatest possible detail by facility in order to facilitate baseline protection. Reporting of emissions from GHG reduction projects should qualify for reporting when they are identified as such, and adhere to equally rigorous quantification standards. GHG emissions reports should be verified through self-certification and NC DENR spot-checks. To qualify for future registry purposes, reports should undergo third-party verification. The reporting program should provide for appropriate public transparency of reported emissions. GHG reporting may be required by DAQ for some categories of sources through normal state rulemaking procedures.

It should be noted that many sources in North Carolina report criteria pollutant emissions to DAQ in order to comply with various federal and state regulatory programs. Most electricity generating units are also required to report carbon dioxide (CO_2) emissions to the US EPA's Acid Rain Program. Some sources may report GHG emissions on a voluntary basis to federal, state, or privately run programs. In addition, the DAQ will be collecting GHG emissions from stationary sources subject to a North Carolina state Title V air permit beginning in calendar year 2008 to fulfill a commitment under the Clean Smokestacks Act. The CAPAG acknowledges these emission reporting programs and DAQ's efforts to systematically integrate the reporting of

GHG emissions by entities to the state in order to minimize costs to both the reporting entities and the state of North Carolina.

CC-3 State Greenhouse Gas Registry

A GHG registry enables uniform measurement and recording of GHG emissions reductions in a central repository. Typically, a registry also includes transaction ledger capability in order to support tracking, management, and ownership of emission reductions. Registries can help encourage sources to undertake GHG reduction efforts, enable potential recognition for such actions, provide baseline protection, and support the crediting of GHG mitigation actions. A registry can also provide a mechanism for regional, multistate, and cross-border cooperation. Subject to appropriately rigorous quantification standards, participation in a GHG registry should not be constrained to particular sectors, sources, or approaches in order to encourage GHG mitigation activities of all types from all quarters. In particular, a GHG registry should be able to incorporate activities associated with all of the options the CAPAG approves, whether reflective of reductions in emissions of GHGs or increases in biological or geological sequestration of carbon.

Building on the GHG reporting program recommended in CC-2, the CAPAG recommends that North Carolina actively engage with other states in developing a regional or national GHG registry that will comprehensively meet the state's needs as soon as possible. If developing regional or national multistate registries does not initially include all of the state's preferred criteria, North Carolina should still join and participate to the greatest extent possible and work to develop whatever additional registry capacity is necessary to meet the remaining needs of North Carolina sources (e.g., registration of carbon sequestered due to reforestation). Together, these approaches should cover all mitigation options the CAPAG recommends, provide adequate quality verification, and allow project-level reporting. Participation by North Carolina sources should be voluntary and include all entities that can verify ownership of GHG emission reductions, and costs should be borne primarily by participants. Entities should be provided the opportunity to participate in a registry as soon as possible after a GHG reporting program is operating.

The CAPAG recommends that the state ensure that any registry in which it decides to participate includes (1) voluntary participation by as broad an array of sectors, sources, facilities, and approaches as possible; (2) participation by entities at least at the statewide level and as broadly (i.e., regionally or nationally) as possible; (3) provisions for sources to start as far back chronologically as good data exists, as affirmed by third-party verification, and allowing registration of project-based reductions or "offsets" that are equally rigorously quantified; (4) incorporation of adequate safeguards to ensure that reductions are not double-counted by multiple registry participants and provide appropriate transparency; (5) maximum consistency with other state, regional, and/or national efforts and the greatest flexibility possible as GHG mitigation approaches evolve; and (6) guidance to assist participants.

In addition, the registry should allow the state and its political subdivisions to be valid participants for registering reductions associated with their programs, direct activities, or efforts, including the registration of emission reductions associated with the stationary and mobile

sources they own, lease, or operate. The state and its political subdivisions should also be allowed to participate in emission trading if and when such a program is developed and authorized. Revenues associated with the sale of any emission reduction credits generated by the state or its political subdivisions could be used to support the GHG emission inventory, forecasting, reporting, and registry functions within state government.

CC-4 State Climate Public Education and Outreach

Public education and outreach can support GHG emissions reduction efforts at a macro- or micro-scale in relation to emissions reduction programs, policies, or goals. Public education and outreach are vital to fostering a broad awareness of climate change issues and effects (including co-benefits, such as clean air and public health) among the state's citizens. Such awareness is necessary to engage citizens in actions to reduce GHG emissions. Public education and outreach efforts should integrate with and build upon existing outreach efforts involving climate change and related issues in the state. Ultimately, public education and outreach will be the foundation for the long-term success of all the mitigation actions proposed by the CAPAG as well as those which may evolve in the future.

The CAPAG recommends that North Carolina lead by example in its own education and outreach activities by establishing a proactive public education and outreach capability and using it to target education and outreach activities to five specific audiences: (1) policymakers and managers (e.g., legislators, regulators, executive branch, agencies, and employees); (2) educators and students; (3) community leaders and community-based organizations (e.g., institutions, municipalities, service clubs, social and affinity groups, and non-governmental organizations); (4) the general public; and (5) industrial and economic sectors (such as professional training, licensing, and certification programs). A statewide public education and outreach effort should probably be overseen largely by NC DENR but would necessarily involve many other key parties. Public education and outreach efforts should commence as rapidly as possible.

CC-5 State Climate Change Adaptation Strategy

Due to the existing buildup in the atmosphere of GHGs that has already occurred, North Carolina will experience some effects of climate change for years to come, even if immediate action is taken to reduce future GHG emissions. Thus, it is essential that the state develop a plan to manage the projected impacts of ongoing climate change while worldwide mitigation efforts to lower atmospheric concentrations are under way.

While taking action to reduce GHG emissions in North Carolina, the state should develop, adopt, and implement a state Climate Change Adaptation Plan that includes identification of (a) potential short-term, mid-term, and long-term impacts of climate change scenarios likely to affect the state, and (b) implementation mechanisms for addressing these impacts. The state should empanel a state-sanctioned Blue Ribbon Commission on Adaptation to Climate Change as soon as possible to develop a state Climate Change Adaptation Plan within one year of establishment of the Commission. The Commission should involve and coordinate with all appropriate state and local agencies, organizations, and institutions (e.g., universities) to ensure that all potential impacts are identified in the plan. The Commission should also enlist the

expertise of all appropriate state and local agencies, organizations, and institutions in developing and implementing measures for mitigating these impacts.

At a minimum, the Commission should address in the plan the adaptation issues that the CAPAG has identified for this option in Appendix I. Benefit-cost analyses should be used to compare the potential costs of a "status quo" approach as opposed to implementing the recommendations proposed in the Climate Change Adaptation Plan. Recommendations in the adaptation plan should be prioritized based on the certainty and severity of adverse impacts to citizens, ecosystems, and local economies. Development of the plan should (a) involve all affected agencies and entities at all levels of government; (b) involve all affected sectors and interests; and (c) provide for periodic review and update concerning adaptation risks, responses, and opportunities in the state. Parallel public education and outreach efforts regarding adaptation should commence immediately. "Early-adoption" opportunities should be addressed as rapidly as possible (even before the Commission is established, if possible), and proactive adaptation initiatives should commence within the next 2–3 years.

The CAPAG also recommends that the State Legislature provide funding to support development and ongoing revision to the state Climate Change Adaptation Plan including, but not limited to, funds to support the cost-benefit analysis needed to guide and inform the development and implementation of the Plan and to cover expenses incurred by the Commission and Commission members.

CC-6 Options for Goals or Targets (for CAPAG in Support of LCGCC)

It is widely anticipated that eventually the federal government may cap GHG emissions associated with global warming. A number of states are ahead of the federal government in establishing GHG caps. For example, the Northeastern States (including New York) have instituted a regional cap-and-trade program to reduce power-sector GHG emissions. California has recently signed into law an economy-wide cap.

North Carolina has successfully severed the link between increasing energy consumption and emissions of soot and smog-forming pollution; even as energy consumption increases, sulfur dioxide and nitrogen oxide pollution are being significantly decreased.

North Carolina should establish voluntary goals to limit GHG emissions to prepare the state's economy for the likely caps at the national level and begin to sever the link between increasing energy demand and GHG emissions. Even modest reductions in GHG emissions will help to align North Carolina's environmental and economic interests and assist the state in addressing its contribution to global warming. The goal would not be mandatory but would simply set a direction in GHG emissions, just like the NC million acre conservation goal.

The CAPAG recommends that the State of North Carolina set an overall voluntary goal to bring statewide emissions back to a baseline, such as year 2000. The goal should be set over a long time horizon of 10–15 years to meet the baseline. It should be expressed as an interim goal on the longer path toward ultimate climate stabilization. There would be no mandates to any specific party. However, all sectors of the state's economy would have the opportunity to contribute toward meeting the state's goal. The adoption of such a goal should first be considered

by the NC LCGCC. If recommended by the LCGCC, such a goal could be established by the General Assembly or by an executive order of the Governor.

The CAPAG identified the following benefits associated with setting a goal to reduce statewide emission:

- **Addressing Potential Global Warming Impacts—**The direct economic toll of global warming on North Carolina may be enormous and would likely include increasing crop loss due to drought, episodic water shortages, coastal flooding and erosion, and building cooling costs. A state goal will draw attention to regional warming trends and associated effects and help business and government prepare for the future.
- **Economic Development—**As the state plans its economic development activities, a state carbon reduction goal can help promote expansion and recruitment of renewable energy technologies that are less GHG intensive. Additionally, these activities will seek to generate jobs in North Carolina to replace the non-native coal and gas sources that currently dominate North Carolina's energy supply.
- **State Leadership—**By establishing a state goal, North Carolina will join the numerous states across the country that are already rising to the challenge of addressing GHG emissions associated with global warming.
- **Business Responsibility—**A state goal will be to provide the motivation and opportunity for companies to examine their options for cost-effective reductions in their GHG emissions. Many companies in North Carolina are already considering the need to reduce carbon dioxide in their long-term planning. A reduction goal will foster the broader business community to consider their ability to also reduce GHG emissions.
- **Preparing for the Emerging Carbon Marketplace—**North Carolina business can potentially sell tens or even hundreds of millions of dollars worth of carbon equivalence credits into the carbon marketplace that national climate legislation will eventually generate. A state goal would help companies that could potentially be suppliers of carbon credits in the coming national marketplace prepare to take advantage of these economic opportunities as soon as they arise.

Appendix A
Description of CAPAG Process

Memo

To: North Carolina Climate Action Plan Advisory Group
From: The Center For Climate Strategies
Date: February 16, 2006

Background

DENR/DAQ Activities

In September 2005, under the Clean Smokestacks Act of 2002 (CSA), the North Carolina Department of Environment and Natural Resources (DENR) and Division of Air Quality (DAQ) delivered a required report to the Environmental Management Commission (EMC) and the Environmental Review Commission (ERC) (of the General Assembly) pursuant to legislative requirements in the CSA that included:

1) Identification and evaluation of carbon dioxide reduction strategies for coal fired utilities and other major stationary sources, and
2) Alternative potential greenhouse gas (GHG) reduction strategies (a limited set of measures beyond carbon dioxide reduction strategies for coal fired utilities and other major stationary sources (identified in step #1), including measures related to other GHG's and sectors)

The final DAQ CSA report to the ERC and EMC included a series of recommendations for state actions on GHG emissions in the stationary source sector, as well as recommended alternative reduction strategies for other sectors. Some actions recommended in the CSA report can be implemented by the state in the near term, while others require further development. Other potential mitigation actions that are likely applicable to North Carolina are not identified in this report. The 2005 DAQ CSA report also includes a comprehensive inventory and forecast of North Carolina GHG emissions from 1990-2020. This assessment was developed using default methodologies from the US EPA State Greenhouse Gas Inventory Tool (SGIT) with substantial augmentation and modification based on the Center for Climate Strategies' (CCS)experience and conferral with DAQ and the SEO. These support tasks were assisted by the CCS.

The CSA report contains a recommendation to continue state GHG mitigation planning through formation of a DAQ stakeholder process to further identify and develop policy actions (recommendation #1) in the form of a Climate Action Plan.

Legislative Activities

During 2005, the General Assembly continued consideration of further legislation on climate change, and ultimately established the North Carolina Legislative Commission on Global Climate Change (the Commission). Section 5 of this Law identifies a number of fact-finding requirements that relate to state-level GHG planning, including determination of the need for a GHG reduction goal and if so, what level of reduction that might be.

Information needs of the Commission may appear to overlap work conducted already under the CSA. However, the goals and process are actually complementary and expected to interface closely with future GHG planning and assessments by DENR/DAQ that are the subject of this memo. The GHG planning process (hereafter referred to as the North Carolina Climate Action Plan Advisory Group (CAPAG), supported by this continuing DAQ/DENR effort is expected to address a number of information gathering needs of the Commission as they relate to climate mitigation policy and work already done pertinent to North Carolina and other states.

Tasks of the CAPAG and Commission Processes

Requested information from the CAPAG and Commission processes, when combined, includes:

(1) GHG emissions inventories and forecasts
(2) Inventories and assessments of impacts of existing and future policy actions
(3) Identification of alternative potential GHG reduction strategies
(4) Assessment of potential benefits and costs
(5) Distribution of costs and benefits
(6) Identification of economic opportunities and impacts
(7) GHG reporting measures
(8) Statewide goals determination (Legislative Commission)

The CAPAG process will be conducted concurrently and in regular communication with the Commission, potentially including regularly being on its meeting agenda. While the two processes are separate, they share some overlapping participants and will communicate through regular briefings (to be scheduled). Findings from the CAPAG process will thus be available for consideration by the Commission at its meetings, and feedback will available for consideration by members of the CAPAG planning process.

Description of the CAPAG Process

Purpose and Goals

The purpose of the CAPAG will be to develop public recommendations to DENR/DAQ for a state-level climate action plan, focusing in particular on economic opportunities. This process also will provide information to the Commission to assist in providing information needs under Section 5 of the Act. The goal of the CAPAG will be to seek consensus on a comprehensive series of individual, potential actions to reduce GHGs in North Carolina. The level of support for specific actions and the full range of CAPAG views will be documented. Statewide targets and or goals, to the extent that they are developed, will be based on results of the Commission's deliberation on this issue.

CCS will provide CAPAG recommendations to DENR/DAQ in a final report to cover the following:

1) Executive Summary
2) Background, Purpose And Goals
    a. Description Of The CAPAG Process
    b. History And Status Of State Actions, Including a Description of State Efforts Underway
    c. Inventory And Forecast Of State Emissions
3) Policy Recommendations
    a. Agriculture and Forestry (also including carbon storage)
    b. Energy Supply (including electricity generation)
    c. Residential, Commercial and Industry (also including industrial process)
    d. Transportation and Land Use (also including biofuels)
    e. Cross-Cutting Issues (including reporting, registries and education)

Process Design

Activities of the CAPAG process will be:

- Stepwise: The process will follow a set master schedule of discussion and decision items and iterate to consensus. As such it will require continuity among participants. CAPAG and technical work group (TWG) participants are expected to regularly attend meetings. Alternates should attend only as needed due to schedule conflicts.
- Fact based: Technical analysis and policy design will be achieved through preliminary and joint fact-finding and, ultimately, joint policy development by CAPAG members and TWGs assisted by a facilitation and technical consulting team (CCS).
- Consensus driven: The state will seek but not mandate consensus through this process, and final decisions by the CAPAG will be made through decision criteria and voting procedures that allow a full expression of viewpoints. Four voting categories will be used, including: *unanimous consent* (all agree), *super majority* (80% agree), *majority* (51% agree) and *minority view* (less than 50% agree).

- Self-determined: The process starts with no pre-commitments to particular policies. Priorities for analysis and final recommendations will be self-determined through informed judgments by the CAPAG and TWGs. CAPAG members will be free to review and suggest revisions to DAQ's September 1, 2005 recommendations under the CSA, including addition of new options to the list of potential options and revisions to the design and implementation of specific options in the CSA report.
- Informal and nonbinding: The process will be advisory and nonbinding to the state to provide public input for potential future policy decisions. It is structured as an informal consensus building effort to provide a full opportunity for CAPAG members to make voluntary decisions on recommended policies.
- Transparent: The processes will be transparent. Policy options will include clear design parameters such as levels, timing, coverage and implementation mechanism. Technical analyses will include clear disclosure of data, methods, sources and assumptions. All proceedings will be posted to the project website by CCS after review for accuracy by DAQ.
- Inclusive: The process will include CAPAG and TWG members, and opportunities for public input.
- Flexible: Throughout the process the facilitation team will check with participants and the state on progress and any potential need for revision. Proposed changes will be shared openly with the group.

Key steps and parameters of the process include the following:

- The CAPAG and TWGs will explore solutions in all sectors, covering: energy supply; commercial, industrial and residential energy use and process related emissions (energy efficiency and conservation); transportation and land use; agriculture and forestry; waste management, and cross-cutting issues.
- The process will start with examination of a compendium of related policy actions undertaken in North Carolina as well as other states and regions, including CSA recommendations, with addition of new options, adaptation to North Carolina circumstances, and prioritization based on CAPAG preferences.
- Mitigation of all GHGs will be examined, including carbon dioxide, methane, nitrous oxide, synthetic gases and, potentially, black carbon. Units will be expressed in metric tons (Mt) carbon dioxide equivalents (CO_2e).
- Historical emissions inventories and reference case projections will be developed for years 1990-2020.
- Recommendations for action will include the present to year 2020, with estimated benefit and cost impacts being reported for 2010 and 2020.
- Recommendations may include state-level and multi-state actions (regional and national), as well as voluntary and mandatory approaches.
- Recommendations will include both quantified and non-quantified actions, with emphasis on numerical analysis of GHG reduction potential and cost effectiveness under available funding and project timetables. Additional issues will be evaluated on a case-by-case basis pending CAPAG input.
- CAPAG discussions will explore alternative policy designs and additional analysis as needed to reach final consensus with assistance from the facilitation team and TWGs.

- The final report will document CAPAG recommendations and views on each policy option, including alternative views as needed.

At the conclusion of the processes, CAPAG recommendations will be presented in a CCS report to DENR/DAQ.

State Leadership And Management

DENR Secretary Bill Ross will convene the CAPAG. DENR/DAQ will organize and coordinate the process with support and assistance by CCS. CCS will report to DENR/DAQ on behalf of CAPAG members and provide facilitation and technical analysis to the CAPAG and TWGs. CCS will provide DENR/DAQ documents for review prior to website posting for CAPAG meetings, and will coordinate with staff on technical assistance, logistical support and other issues as needed.

State agency representatives will serve as voting members and/or nonvoting technical advisors of the CAPAG and TWGs. DAQ will oversee the CAPAG process in coordination with CCS, assist CCS with planning and implementation of the process and provide input on policies and issues identified by CAPAG members, the public and TWGs as needed. The state will provide logistical support for meetings, facilities, public notice and posting of materials as needed, with assistance and coordination by CCS.

CAPAG Members

A group of public participants representing a variety of North Carolina organizations and companies selected by the DENR/DAQ and invited to be members of the CAPAG, include broad economic sectors in the state. They will be tasked with making formal decisions and developing recommendations on policy actions with assistance by the CCS team.

TWG Members

TWG members will be comprised primarily of CAPAG members assigned to specific sectors of interest. These TWGs will be augmented with additional technical experts and interested parties as needed. They will be selected by the state with assistance from CCS. TWGs will be organized at the first CAPAG meeting. The TWGs will advise the CAPAG and complete tasks designated by the CAPAG as priorities. TWGs will cover all sectors that include: 1) energy supply (including electricity and natural gas), 2) commercial, industrial and residential (including energy efficiency and conservation), 3) transportation and land use, 4) agriculture and forestry, and 5) cross-cutting issues (such as reporting, registries, and education).

TWGs will be tasked with providing guidance to CAPAG members on priorities for analysis, technical analysis and design of options, alternative approaches, and final recommendations.

The Public

The meetings of the CAPAG will be conducted in accordance with open meetings and public information requirements and policies in effect for the state. Meeting notices, advance materials and minutes of previous proceedings will be made available to the public through the project Web site and other means. Public input may be provided as a routine designated part of CAPAG meetings.

Participant Guidelines

CAPAG and TWG members are expected to follow certain codes of conduct during the process, including:

- Attendance is strongly requested at all meetings to provide continuity to the stepwise process. Alternates may be named when absolutely necessary.
- Active involvement in proposals and evaluations is needed from each member to fully support the process of joint policy development.
- Good faith participation and full support of the process are required.
- In exchanging information and views, CAPAG members should make fact-based offers and statements, and refrain from personal criticisms.
- CAPAG and TWG members should not represent the state or CAPAG in contacts with the media.

Facilitation

CCS will serve as facilitator of the CAPAG and TWGs. Facilitation responsibilities include:

- Reporting to DENR/DAQ on behalf of CAPAG members and providing coordination and management support for the CAPAG process
- Direction and coordination of technical consultants and TWG leaders, including meetings and calls
- Planning and supervision of CAPAG meetings, calls, reports and documents
- Facilitation and management of CAPAG meetings
- Coordination of CCS activities with DENR/DAQ and other state agency technical and support staff as needed
- Conducting public meetings as needed

To support facilitation and project management, CCS will provide a project website (www.ncclimatechange.us) for use by participants. DAQ will approve the design of the site and documents for posting by CCS. CCS will be responsible for posting documents and managing the site following DAQ approval. At the conclusion of the process, public materials from the website will be transferred to DENR/DAQ for ongoing management and use by the state.

As a part of its role as evaluative facilitator, CCS voluntarily abides by the model standards of conduct by the American Arbitration Association, American Bar Association and the Association

for Conflict Resolution as applicable to the advisory process as an informal, consensus building initiative.

Technical Team

The CCS technical team will serve as a neutral and expert group to inform and support the development of technical and policy consensus. Technical staff will perform analyses and provide support based on CAPAG and TWG decisions. The team will be composed of the process facilitator and five TWG leaders. Other consultants will be deployed as needed for specialized analysis or additional capacity. State agency staff and TWG members will be asked to assist CCS in formulation and analysis of options.

Fact Finding

Preliminary fact finding prior to the first CAPAG meeting will include:

- Development of a draft emissions inventory and reference case forecast (completed under the DENR/DAQ CSA report)
- Identification of a compendium of conceivable options for CAPAG augmentation and consideration (completed under the 2005 DAQ CSA report), including potential actions identified under the 2005 DAQ CSA report.

Joint fact finding after the first CAPAG meeting will include:

- Finalization of GHG emissions inventories and reference case forecasts for sectors
- Identification of a “long list” compendium of conceivable policy options in North Carolina
- Identification of actions already underway in North Carolina
- Ranking and identification of initial priorities for analysis
- Development of initial policy design parameters and evaluation methods (including technical agreement on appropriate data sources, methods and assumptions for analysis of policy options), and joint model development as needed
- Identification and analysis of alternative policy designs, including implementation mechanisms
- Final benefit and cost analysis, and related analysis of secondary impacts, and ancillary and feasibility issues as needed
- Identification of cross-cutting issues and integrated policy analyses as needed
- Statewide and sector based economic modeling, as necessary

Timing and Milestones

The first meeting of the CAPAG is scheduled for launch February 16, 2006, with up to five additional CAPAG meetings to be held through late winter of 2007. We plan for one or two TWG conference calls to be held between CAPAG meetings as needed, along with interim briefings and reports to DENR, EMC, ERC and the Legislative Commission, according to a schedule to be determined by the DENR/DAQ. A final report with CAPAG recommendations will be provided to DENR/DAQ by June 30, 2007, and earlier if possible, following a period of review by the CAPAG and the public.

Draft Project Calendar

February 2006	1st CAPAG meeting
April 2006	2nd CAPAG meeting
June 2006	3rd CAPAG meeting
August 2006	4th CAPAG meeting
October 2006	5th CAPAG meeting
February 2007	6th CAPAG meeting
May, 2007	Report review
June 2007	Final DENR/DAQ Report Due
Between CAPAG Meetings	TWG conference calls, briefings and reports as needed.

Draft CAPAG And Technical Work Group Meeting Agendas

MEETING ONE

- Introductions
- Purpose and goals
- Review of the CAPAG process and its relation to CSA and the Commission
- Review of CSA recommendations by DENR
- Identification and recognition of existing actions being taken in North Carolina and other states
- Emissions inventory & forecasts
- Key policy opportunities & issues
- Formation of TWGs, next meeting agenda

Interim TWG calls (to be scheduled by CCS) will cover: 1) suggested revisions to the draft inventory and reference case projections, 2) review and suggested modifications to the “long list” of policy options, 3) early ranking of options and suggested initial priorities for analysis, including CSA recommended options

MEETING TWO

- Recommended updates to inventories and baseline forecasts
- Discussion of additional "long list" of conceivable additional North Carolina policy actions
- Review and discussion of initial priorities for TWG analysis
- Review of TWG plans, including quantification
- Identification of cross-cutting issues

Interim TWG calls to cover: 1) suggested final revisions to the emissions inventory and reference case projections, 2) suggested modifications to the list of initial priorities for analysis for CAPAG review, 3) suggested policy designs for specific policy actions for CAPAG review, 4) next steps on design and analysis of initial policy options

MEETING THREE

- Final agreement on inventories and baseline forecasts
- Approval of TWG lists of policy priorities for analysis
- Discussion of policy design and implementation mechanisms for policy options, process for developing straw proposals
- Briefing on cross cutting issues and policy options

Interim TWG calls to cover: 1) development of straw proposals for design parameters for individual options, 2) identification of potential implementation mechanisms for options, 3) next steps for analysis of options, 4) identification of cross-cutting policy needs

MEETING FOUR

- Review of policy options list, straw proposals for policy design, and early results of analysis
- Guidance to TWGs on additions, deletions and modifications of options
- Identification of alternative policy designs and implementation mechanisms for TWGs, as needed
- Review and revision of cross cutting policy options

Interim TWG calls to cover: 1) revisions to draft final policy priorities and design parameters, including implementation mechanisms, 2) next steps for draft analysis of options and design alternatives, and 3) next steps on formulation of cross cutting policy options and mechanisms

MEETING FIVE

- Review of options list, with results of analysis and cumulative emissions reductions potential
- Identification of consensus and non consensus options

- Identification of barriers and alternatives for non consensus options, with guidance for additional work on options to TWGs
- Review of final report progress and plans

Interim TWG calls to cover: 1) final revisions to design parameters, including implementation mechanisms, 2) final analysis of options, alternatives, and 3) final steps on formulation of cross cutting policy options and mechanisms

MEETING SIX

- Progress report on non-consensus policy options list and cumulative emissions reductions potential
- Identification of consensus and non consensus options from remaining list
- Identification of barriers and alternatives for non consensus options, proposals for resolution by the CAPAG
- Discussion and final resolution of barriers and determination of consensus for remaining options
- Summary of the process, review of next steps for review and transmittal of the final report

CCS team completes CAPAG updates to policy options and draft final report language.

PUBLIC REVIEW OF THE DENR/DAQ REPORT

FINAL DENR/DAQ REPORT

Appendix B
Members of Technical Work Groups

*Also a member of CAPAG
( ) Names in parentheses also served as alternates

Residential, Commercial, and Industrial

John Calcagni, NC DENR Division of Pollution Prevention and Sustainability
Jerry Coker, Weyerhaeuser*
Kristen Coracini, Environmental Defense
Steve Halsted, North Carolina Council of Churches*
Joe Harwood, Duke Energy
Len Hoey, North Carolina State Energy Office
Gary Hunt, NC DENR Division of Pollution Prevention and Sustainability*
Edward Kreul, International Paper
Ward Lenz, Advanced Energy
James McLawhorn, Public Staff of NC Utilities Commission
Steven McNulty, USDA Forest Service Southern Global Change Program*
Libby Smith, North Carolina Department of Commerce*
Dona Stankus, North Carolina Solar Center
Ralph Taylor, North Carolina State Construction Office
Jeff Tiller, Appalachian State University
Mitch Williams, Progress Energy
Matt Young, Cherokee Investments

David Von Hippel, CCS, TWG Facilitator
Alison Bailie, CCS, TWG Facilitator
Charles Davis, TWG Liaison, DENR/DAQ
Brock Nicholson, DENR/DAQ Coordinator

Energy Supply

Caroline Choi, (replaced Vicky Will), Progress Energy*
Marion Deerhake, Environmental Management Commission*
James DeRosa, (Jim Haven), Global Warming Initiatives
Roy Ericson, NC Utilities Commission*
George Everett, Duke Energy*
Alex Hobbs, NCSU Solar Center*
Len Hoey, State Energy Office
Preston Howard, Manufacturer Chemical Industry Council*
Matthew Kanes, (Steve Lisk), Piedmont Natural Gas
Robert Koger, (Ward Lenz), Advanced Energy*
Thomas Lam, Public Staff of NC Utilities Commission
Pete McDowell, NC Waste Awareness and Reduction Network
Marily Nixon, Southern Environmental Law Center*
Simon Rich, Energy Industry & Duke University*
Michael Shore, (Ulla Reeves, Amy McDonald), Environmental Defense*
Jim Stephenson, NC Coastal Federation*

Tim Toben, Carolina Green Energy*
Ivan Urlaub, NC Sustainable Energy Association*
John Wilson, (Stephen Smith*), Southern Alliance for Clean Energy

Bill Dougherty, CCS, TWG Facilitator
Sivan Kartha, CCS, TWG Facilitator
Kimberly Garnett, TWG Liaison, DENR/DAQ
Jim Southerland, DENR/DAQ
Brock Nicholson, DENR/DAQ Coordinator
Charles Davis, DENR/DAQ

Transportation and Land Use

Daren Bakst, John Locke Foundation
Dan Besse, Winston-Salem City Council*
Denise Choy, Environmental Defense
Anne Coan, NC Farm Bureau
David Farren, (Marily Nixon*), Southern Environmental Law Center
Dennis Grady, Appalachian State University*
Len Hoey, State Energy Office
Bill Holman, Clean Water Management Trust Fund, then Duke University, Nicholas Institute for Environmental Policy Solutions*
Scott Lane, Louis Berger Group
Carolyn McCormick, Outer Banks Visitors Bureau*
Maximilian Merrill, NC Department of Agriculture and Consumer Services
Simon Rich, Energy Industry & Duke University*
Lisa Riegel, NC Natural Heritage Trust Fund*
Roger Sheats, Global Warming Initiatives*
Nina S. Szlosberg, NC Board of Transportation*
Anne Tazewell, NC Solar Center Alternative Fuels
Jeff Tiller, Appalachian State University
Susan Tompkins, Community Volunteer
Skip Yeakel, Volvo Trucks North America*

William Schroeer, CCS, TWG Facilitator
Wendy Messenger, (Lewison Lem), CCS, TWG Facilitator/Assistants
Karl Hausker, CCS, TWG Facilitator
Phyllis Jones, TWG Liaison, DENR/DAQ
Brock Nicholson, DENR/DAQ Coordinator

Agriculture, Forestry, and Waste Management

Stan Adams, NC DENR, Division of Forestry Resources (now retired, but active)*
John Bonitz, Rural Advancement Foundation and Southern Alliance for Clean Energy
Anne Coan, (Mitch Peele, Paul Sherman*) North Carolina Farm Bureau
Marion Deerhake, Environmental Management Commission*
Jim Durham, International Paper
Bob Hazel, Senior Citizens' Interest*
Dennis Hazel, NCSU, Forestry Extension*
Jim Hickman, NC Division of Pollution Prevention and Environmental Assistance

Bill Holman, Clean Water Management Trust Fund, then Duke University, Nicholas Institute for Environmental Policy Solutions*
Chris Hopkins, NCSU, Forestry Extension
Robert Jackson, Duke University, Nicholas School of the Environment and Earth Sciences*
Amy McDonald, Environmental Defense & Southern Alliance for Clean Energy
Steve McNulty, USDA Forest Service, Southern Global Change Program*
Maximilian Merrill, NC Department of Agriculture and Consumer Services*
David Mickey, Blue Ridge Environmental Defense League
Bob Slocum, North Carolina Forestry Association*
Stephen Smith, (Ulla Reeves) Southern Alliance for Clean Energy*
Jim Stephenson, NC Coastal Federation
Kraig Westerbeek, Murphy-Brown Farms*
Stephen Whitfield, North Carolina Woodlands*

Steve Roe, CCS, TWG Facilitator
Kathryn Bickel, CCS, TWG Facilitator
Heather Hawkins, TWG Liaison, DENR/DAQ
Jim Southerland, DENR/DAQ
Brock Nicholson, DENR/DAQ Coordinator

Cross-Cutting Issues

Dan Besse, Winston-Salem City Council*
Ryan Boyles, State Climatologist, (replaced Sethu Raman) NC Climate Office*
Thomas F. Cecich, Environmental Management Commission*
Dolores M. Eggers, Professor, UNC Asheville*
George Givens, Principal Legislative Analyst, Attorney at Law, General Assembly of North Carolina, Council to the Environmental Review Commission of the General Assembly of North Carolina and the Legislative Commission on Global Climate Change*
Steve Kalland, NC Solar Center
Steven McNulty, USDA Forest Service, Southern Global Change Program*
Chuck Pickering, The Biltmore Estate*
Ulla Reeves, Southern Alliance for Clean Energy
Roger Sheats, (James DeRosa, Jim Haven), Global Warming Initiatives*
Larry Shirley, North Carolina State Energy Office*
Michael Shore, (Kathryn Eggers), Environmental Defense*
Libby Smith, NC Department of Commerce*
Jim Stephenson, NC Coastal Federation*
Susan Tompkins, Community Volunteer

Ken Colburn, CCS, TWG Facilitator
Randy Strait, CCS, TWG Facilitator
James Southerland, TWG Liaison, DENR/DAQ
Brock Nicholson, DENR/DAQ Coordinator
Janice Godfrey, DENR/DAQ

Appendix C
Greenhouse Gas (GHG) Emissions Inventory and Reference Case Projections

See the report titled "Final North Carolina Greenhouse Gas Inventory and Reference Case Projections 1990–2020," dated September 2007, for detailed documentation. The report is available on the Climate Action Plan Advisory Group's Web site at http://www.ncclimatechange.us/capag.cfm.

Appendix D
Methods for Quantification

Draft Memo

To: North Carolina Climate Action Planning Advisory Group (CAPAG) and Technical Work Group (TWG) members
From: The Center for Climate Strategies (CCS)
CC: North Carolina Department of Environment and Natural Resources (DENR)
Re: Methods for quantification of draft greenhouse gas (GHG) mitigation option benefits and costs
Date: May 23, 2006

This memo describes in brief the methodology CCS uses in quantifying the GHG impacts and costs of policy options, and provides some examples of the distinction between "direct" and "indirect" costs. CCS uses the following methods, widely accepted among climate change mitigation policy analysts:

- Focus of analysis: Net GHG reduction potential in physical units of million metric tons carbon dioxide equivalent ($MMtCO_2e$) and net cost per metric ton reduced in units of dollars/$MtCO_2e$.

- Geographic inclusion: Measure GHG impacts of activities that occur within the state, regardless of the actual location of emissions reductions.

- Direct vs. Indirect Effects: Define "direct effects" as those borne by the entities implementing the option. For example, direct costs are net of any benefits or savings to the entity. Define "indirect effects" as those borne by the entities other than those implementing the option. Quantify these indirect effects on a case-by-case basis depending on magnitude, importance, need, and availability of data. (See additional discussion and list of examples below.)

- Non-GHG (ancillary) impacts and costs: Include in qualitative terms where deemed important. Quantify on a case-by-case basis as needed, depending on need and where data are readily available.

- Discounted and "Levelized" Costs: Discount costs using the discount rate applied by the State in other policy arenas (or apply a real discount rate of 5% if a state-approved rate is not available). Discount a multiyear stream of net costs (total costs net of any savings) to arrive at the "present value cost" of an option. Create a "levelized" cost per ton by dividing the "present value cost" by the cumulative reduction in tons of GHG. This is a widely used method to estimate the "dollars per ton" cost of reducing GHG emission (all

in CO_2 equivalence). A "levelized" cost is a "present value average" used in a variety of financial cost applications.[1]

- Time period of analysis: Count the impacts of actions that occur during the project time period and, using levelized emissions reduction and cost analysis, report emissions reductions and costs for specific target years such as 2010 and 2020. Where additional GHG reductions or costs occur beyond the project period as a direct result of actions taken during the project period, show these for comparison and potential inclusion.

- Aggregation of impacts: Avoid simple double counting of GHG reduction potential and cost when adding options. Note and or estimate interactive effects between policy options using analytical methods where overlap is likely.

- Policy design specifications: Include timing, goal levels, implementing parties, and the type of implementation mechanism.

- Transparency: Include data sources, methods, key assumptions, and key uncertainties.

The approaches here do not necessarily take a "standard" benefit-cost perspective as used in regulatory policy impact analysis. For instance, there is no direct/indirect distinction under standard procedures: one takes the "societal perspective" and tallies everything and quantifies where possible. Regarding GHG mitigation costs, often the best available data are focused at the level of implementation as opposed to the societal level. Regarding GHG benefits, market prices (monetized benefits) are normally taken as good proxies of societal costs and benefits in standard analysis unless there are market imperfections or subsidies that create distortionary effects. Because we do not have good information on the dollar value of GHG reduction benefits, we use physical benefits instead, measured as $MMtCO_2e$.

The "direct cost" approach described here is useful in estimating the costs (and benefits) to the implementing entity: person, company, governmental body, etc. "Indirect costs" (and benefits) are those experienced by other entities in society. In examining utility Demand-Side Management (DSM) programs for gas and electric utilities, analysts sometimes look at three perspectives: "participant," "non-participant," and "societal" (the latter being equivalent to "standard" benefit-cost perspective). Depending on program design, "direct cost" to a DSM participant can be high or low (if the latter, it may be attributable to a shifting of some costs to non-participants).

Note also that the "direct cost" approach does not necessarily account for market imperfections or subsidies. Typically a state perspective on "direct costs" takes any federal government subsidies as a given. For example, substantial federal government subsidies exist for some alternative fuels. If the existing market price (with subsidy) of the alternative fuel is used in cost analysis, the option appears as relatively low cost. If the subsidy were included in the cost

[1] For additional details and formulas, see www.tellus.org/energy/publications/policies&measures.pdf, p. 33. See especially the discussion of how some analysts advocate some form of discounting the multi-year stream of GHG reductions, while others do not.

analysis (i.e., looking at societal costs in the standard benefit-cost perspective), then the alternative fuel would appear more costly.

Finally, some direct costs may look very large despite the attractiveness of the policy option for a variety of reasons, including co-benefits. For instance, in one state, a bundle of Transit/Smart Growth/vehicle miles traveled (VMT) Reductions was estimated to have a direct cost of \$280/MtCO_2e—a comparatively high figure—but stakeholders still endorsed the policy option for the multiple benefits it would generate. In this case, stakeholders also believed that a large state investment cost would have been incurred anyway for conventional transportation investment, and that redirection of part of this existing stream of funds to smart growth alternatives made sense. As an alternative assumption, the cost of the existing stream of transportation funds could have been treated as sunk, and the true cost measured instead as the incremental level of smart growth redirected funding over and above the business-as-usual (BAU) funding stream.

CCS will provide transparency on related data sources, methods, and assumptions in its analysis of draft mitigation policy options to ensure that these issues are known, and will rely on feedback from the TWGs and CAPAG to identify any suggested modifications that may be needed. One key constraint we often face is the availability of data. It is not unusual for data to be imperfect and require pragmatism and transparency during analysis.

For additional reference, we recommend the economic analysis guidelines developed by the Science Advisory Board of the United States Environmental Protection Agency (US EPA) available at: http://yosemite.epa.gov/ee/epa/eed.nsf/webpages/Guidelines.html.

Examples of Direct/Indirect Net Costs and Benefits, RCI

Direct Costs and/or Benefits

- Net capital costs (or incremental costs relative to standard practice) of improved buildings, appliances, equipment (cost of higher-efficiency refrigerator versus refrigerator of similar features that meets standards)
- Net operations and maintenance (O&M) costs (relative to standard practice) of improved buildings, appliances, equipment, including avoided/extra labor costs for maintenance (less changing of compact fluorescent lamp [CFL] or light-emitting diode [LED] lamp relative to incandescent)
- Net fuel (gas, electricity, biomass, etc.) costs (typically as avoided costs from a total resource cost (TRC) or societal perspective)
- Cost/value of net water use/savings
- Cost/value of net materials use/savings (for example, raw materials savings via recycling, or lower/higher cost of low-GWP global warming potential] refrigerants)
- Direct improved productivity as a result of industrial measures (measured as change in cost per unit output, for example, for an energy/GHG-saving improvement that also speeds up a production line or results in higher product yield)

Indirect Costs and/or Benefits

- Re-spending effect on economy
- Net value of employment impacts
- Net value of health benefits/impacts
- Value of net environmental benefits/impacts (value of damage by air pollutants on structures, crops, etc.)
- Net embodied energy of materials used in buildings, appliances, equipment, relative to standard practice
- Improved productivity as a result of an improved working environment, such as improved office productivity through improved delighting (though the inclusion of this as indirect might be argued in some cases)

Examples of Direct/Indirect Net Costs and Benefits, ES

Direct Costs and/or Benefits

- Net capital costs (or incremental costs relative to reference case technologies) of renewables or other advanced technologies resulting from policies
- Net O&M costs (relative to reference case technologies) renewables or other advanced technologies resulting from policies
- Avoided or net fuel savings (gas, coal, biomass, etc.) of renewables or other advanced technologies relative to reference case technologies resulting from policies
- Total system costs (net capital + net O&M + avoided/net fuel savings + net imports/exports + net T&D [transmission and distribution] costs) relative to reference case total system costs

Indirect Costs and/or Benefits

- Re-spending effect on economy
- Higher cost of electricity reverberating through economy
- Energy security
- Net value of employment impacts
- Net value of health benefits/impacts
- Value of net environmental benefits/impacts (value of damage by air pollutants on structures, crops, etc.)

Examples of Direct/Indirect Net Costs and Benefits, AFW

Direct Costs and/or Benefits

- Net capital costs (or incremental costs relative to standard practice) of facilities or equipment (e.g., manure digesters and associated infrastructure, generator; ethanol production facility)
- Net O&M costs (relative to standard practice) of equipment or facilities
- Net fuel (gas, electricity, biomass, etc.) costs or avoided costs
- Cost/value of net water use/savings

Indirect Costs and/or Benefits

- Net value of employment impacts
- Net value of health benefits/impacts
- Value of net environmental benefits/impacts (value of damage by air pollutants on structures, crops, etc.)
- Net embodied energy of water use in equipment or facilities relative to standard practice
- Reduced VMT and fuel consumption associated with land use conversions (e.g., as a result of forest/rangeland/cropland protection policies)

Examples of Direct/Indirect Net Costs and Benefits, TLU

Direct Costs and/or Benefits

- Incremental cost of more efficient vehicles net of fuel savings
- Incremental cost of implementing Smart Growth programs, net of saved infrastructure costs
- Incremental cost of mass transit investment and operating expenses, net of any saved infrastructure costs (e.g., roads)
- Incremental cost of alternative fuel, net of any change in maintenance costs

Indirect Costs and/or Benefits

- Health benefits of reduced air and water pollution
- Ecosystem benefits of reduced air and water pollution
- Value of quality-of-life improvements
- Value of improved road safety
- Energy security
- Net value of employment impacts

Appendix E
Residential, Commercial, and Industrial Sectors Mitigation Option Recommendations

Summary List of Mitigation Option Recommendations

Option No.	Mitigation Option Name	GHG Reductions ($MMtCO_2e$)			Net Present Value 2007–2020 (Million $)	Cost-Effective-ness ($/$tCO_2e$)	Level of Support
		2010	2020	Total 2007–2020			
RCI–1	Demand-Side Management Programs for the Residential, Commercial and Industrial Sectors Recommended Case: "Top-ten States" EE Investment	1.9	11.6	77.1	–1,895	–25	UC
RCI–2	Expand Energy Efficiency Funds	1.5	8.0	54.8	–1,346	–25	UC
RCI–3	Energy Efficiency Requirements for Government Buildings	0.0	1.1	6.4	–88	–14	UC
RCI–4	Market Transformation and Technology Development Programs	0.0	2.0	10.5	–339	–32	UC
RCI–5	Improved Appliance and Equipment Efficiency Standards	0.0	1.0	5.3	–336	–63	UC
RCI–6	Building Energy Codes	0.5	3.5	23.1	–400	–17	UC
RCI–7	"Beyond Code" Building Design Incentives and Targets, Incorporating Local Building Materials and Advanced Construction	0.7	5.2	34.2	–494	–14	UC
RCI–8	Education (Consumer, Primary/Secondary, Post-Secondary/ Specialist, College and University Programs)	*Not quantified*					UC
RCI–9	Green Power Purchasing (required for state facilities) and Bulk Purchasing Programs for Energy Efficiency or Other Equipment	0.1	0.5	3.5	11	3	UC
RCI–10	Distributed Renewable and Clean Fossil Fuel Power Generation	1.2	4.6	33.5	392	12	UC
RCI–11	Residential, Commercial, and Industrial Energy and Emissions Technical Assistance and Recommended Measure Implementation	0.5	2.1	14.9	–494	–33	UC
	SECTOR TOTAL AFTER ADJUSTING FOR OVERLAPS	5.3	33.0	218.7	–3,994	–18	N/A
	REDUCTIONS FROM RECENT ACTIONS*						
RCI–1	Demand-Side Management Programs for the Residential, Commercial and Industrial Sectors	0.3	0.7	6.2			N/A
RCI–2	Expand Energy Efficiency Funds	0.2	0.4	3.6			N/A
RCI–6	Building Energy Codes	0.0	0.0	0.0			N/A
RCI–9	Green Power Purchasing (required for state facilities) and Bulk Purchasing Programs for Energy Efficiency or Other Equipment	0.0	0.0	0.3			N/A
	SECTOR TOTAL PLUS RECENT ACTIONS	5.8	34.2	228.8			N/A

UC = unanimous consent; N/A = not applicable.

Negative values in the Net Present Value and the Cost-Effectiveness columns represent net cost savings associated with the options.

* "Recent actions" represent initiatives undertaken in North Carolina that reduce GHG emissions that were implemented shortly before or during the Climate Action Plan Advisory Group (CAPAG) process. The emission reductions associated with recent actions are not accounted for in the GHG emissions inventory and reference case projections. Emissions reductions associated with these recent actions were therefore estimated separately, and are counted toward overall statewide reductions along with reductions from the mitigation options recommended by the CAPAG.

Notes

Substantial input on **Related Policies/Programs in Place** was provided by RCI Technical Work Group (TWG) members, especially focusing on State Energy Office (SEO) and State Energy Plan (SEP) policies and programs**.** Because many of these policies and programs are relevant to more than one of the RCI Options, we have established Annex A (provided with analysis workpapers—Annex B—accompanying this document.) that provides details on these policies and have retained only the titles of the policies in the "Related Policies/Programs section for the RCI individual options. SEO Contract refers to contracts currently in place with the State Energy Office for the services outlined.

RCI-1. Demand-Side Management Programs for the Residential, Commercial, and Industrial Sectors

Mitigation Option Description

Utility-funded Demand-Side Management (DSM) programs reduce either the consumption of or the demand for conventional sources of electricity and fossil fuels. Examples of DSM programs include technical assistance for and implementation of energy efficiency and renewable energy measures, electrical (and in some cases fuel) demand responses, alternative rate schedules, and research activities. This option is designed to work in tandem with other strategies under consideration by the Residential, Commercial, and Industrial (RCI) Technical Work Group (TWG) and by other TWGs that can also encourage efficiency gains.

Mitigation Option Design

It is recommended that DSM programs funded by gas and electric utilities in North Carolina be expanded to yield higher levels of energy savings, demand response, and greenhouse gas (GHG) emissions savings.

Specific recommendations from the RCI TWG include proposing that the North Carolina General Assembly and the North Carolina Utilities Commission (NCUC) take an active role in encouraging the investor-owned, cooperative and municipal utilities to pursue active DSM programs.

Examples of utility-funded programs that this option supports include

Residential Building Programs

- Efficiency programs for new residences, such as ENERGY STAR®, Environments for Living, HealthyBuilt Homes, and the Green Building Council's Leadership in Energy and Environmental Design new program for homes (LEED-H), or other programs.
- Efficiency programs for existing residences, such as Home Performance with ENERGY STAR. Development of this program should follow a comprehensive survey and analysis of existing residences to determine key strategies that will provide the greatest impact for the least investment.
- Renewable energy programs for new and existing residences.[1]
- Programs focused on low-income weatherization of new and existing homes (such as Systems Vision).
- Programs focused on rental properties.

[1] Including cost-effective alternatives to fossil-fuel-based energy, such as solar water heating, passive solar designs, solar space heating and pool heating (only to replace electric or fossil-fuel-based existing pool heating), residential biofuels, photovoltaics, and other strategies.

Commercial and Industrial Building Programs

- Efficiency programs for new commercial buildings, using commercial ENERGY STAR and LEED-NC as starting points.
- Efficiency programs for existing commercial buildings, using the work of the SEO's Utility Savings Initiative, ongoing energy audit and technical services, and previous programs, such as the federally funded Institutional Conservation Program, and programs in other states, as additional sources.
- Efficiency programs for new and existing industrial facilities, based on ongoing efforts of North Carolina State's Industrial Energy Extension Service and Industrial Assessment Center, Advanced Energy's industrial efficiency programs, and other related projects.
- Renewable energy programs for new and existing commercial buildings and industrial facilities, with the same focus as renewable energy programs for new and existing residences.

Other Multi-sector Strategies

- Demand response and demand reduction programs for all sectors.
- Technical assistance, education, training, consumer outreach, and promotional activities to support the DSM programs.
- Grants, loans, performance contracting arrangements, and other incentive programs to provide financial support or incentives for implementation of DSM programs.

Goals: The goal for this option is to reach a level of DSM investment in North Carolina equal to 1.5% of utility revenues. This level of investment would have placed North Carolina among the top ten US States in DSM investment per unit electricity sales revenue, based on a national compilation of energy efficiency investment for the year 2003.[2]

Timing: Start ramping up programs from existing levels starting in 2007, reaching goal levels by 2012.

Parties Involved:

- Utilities: Through the rate-making process, utilities and the NCUC will develop a mechanism to include the cost of DSM programs in the respective utility's rate base, or provide for a separate surcharge that utility customers pay.
- State Agencies: The NCUC, the Public Staff, the SEO, the Department of Environmental and Natural Resources (DENR), the State Construction Office, and others shall be involved in the design and implementation of the DSM programs.
- Third-party Efficiency Providers: North Carolina has considerable expertise in its universities, nonprofit organizations, and private consulting and technical service companies to provide services for the DSM programs. The overall effort should seek to develop a

[2] American Council for an Energy-Efficient Economy's (ACEEE's) *3rd National Scorecard on Utility and Public Benefits Energy Efficiency Programs: A National Review and Update of State-Level Activity,* Dan York and Marty Kushler, American Council for an Energy-Efficient Economy. Report No. U054, October 2005. See also rankings in *A Study of the Feasibility of Energy Efficiency as an Eligible Resource as Part of a Renewable Portfolio Standard for the State of North Carolina,* December 2006, prepared for the NCUC by GDS Associates, Inc.

statewide "efficiency industry" that will expand beyond the efforts of the DSM programs alone.

- Regulators: The NCUC, with input from the Public Staff, will likely be the approving and oversight body for the programs.
- Others: A wide variety of stakeholders will provide input into the development and continued operation of the DSM programs.

Implementation Mechanisms

Demand-Side Management programs around the country vary substantially, with dozens of different types of implementation mechanisms. Potential implementation mechanisms and supporting activities for this mitigation option include the following:

- Primary Implementation Mechanism—Utilities will develop and manage their own Demand-Side Management Programs, with input from the NCUC and other stakeholders, and with approval from the NCUC, and will include the expenses of the program in the overall rate base.[3]
- Overall Management—There are different options for overall management of utility programs:
  - Each utility manages its own programs.
  - Utilities contract with others (public agencies, nonprofit agencies, and/or private contractors) to manage some or all of a utility's programs.
- Supporting Activities:
  - Direct payment incentive programs: Utility customers who implement specific efficiency or renewable measures receive partial rebates. For example, builders of ENERGY STAR homes receive an incentive of a given amount per square foot up to a maximum incentive.
  - Rebate programs: Utility customers who purchase energy efficient or renewable products receive an incentive payment upon submitting their purchase receipts.
  - Loan programs: Utility customers receive a preferential loan to finance the purchase of high-efficiency heating, ventilation, and air conditioning (HVAC) systems for commercial buildings.
  - Preferential rates: Participants in load control programs or homebuyers who select (for example) ENERGY STAR homes receive lower rates.
  - Marketing programs: Utilities purchase advertising to promote the DSM programs and recognize those who participate.[4]
  - Technical service programs: Utilities provide directly, through the managing organization, or through subcontractors, technical assistance, analysis, and recommendations.

[3] The NCUC might also consider offering utility incentives to provide substantial programs.

[4] Marketing on consumer products programs can include incentives, retailer training, marketing and promotion, education, and similar efforts.

- Research and development (R&D) programs: Utilities support applied research which promises fairly quick implementation, such as high-efficiency HVAC and humidity control systems, insulated/non-vented attics, improved commercial ventilation control strategies, and electricity generation from biomass.[5]

Related Policies/Programs in Place

- **State Energy Office (SEO) Contract, Appalachian State University Energy Center.**
- **State Energy Plan (SEP) Exec-11:** Reduction of energy consumption in State agencies and universities.
- Electric Utilities providing DSM programs include Progress Energy, Dominion Power, and Duke Energy. Programs are mostly information, with a few financing programs.[6] Gas utilities and other fuel provider organizations include Piedmont Natural Gas, Scana – Public Service Company North Carolina (PSCNC), North Carolina Propane Gas Association, North Carolina Petroleum Marketers Association, and Carolina Fuel Institute.
- At the May 23 Climate Action Plan Advisory Group (CAPAG) meeting, the Environments for Living program was noted as an example, with builders having built 80,000 homes in the South and Southwest under the program in the last 5 years.[7] Also, it was noted that solar water heating is included in the NC Green Power Program.
- The NC HealthyBuilt Homes (HBH) program, supported in part by the NC SEO, has been very active in the State.
- ENERGY STAR Homes is another example of building performance standards and certifications in use in North Carolina.
- Policy on net metering has been established by the NCUC, and corresponding tariffs approved.[8] The establishment of Small Generator Interconnection Standards is designed to streamline the process for customers seeking to install net metering applications, as well as other small renewable energy generation applications.[9]
- Free refrigerator disposal programs already exist in North Carolina.
- In 1980, the NCUC established a systems benefit charge, creating a nonprofit corporation to administer the funds with the charter "to encourage energy efficient economic development in North Carolina." The nonprofit Advanced Energy operates programs for subsidized and

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[5] Such support can include funding of research and development for energy efficiency and renewable energy and could be implemented through R&D contracts with private firms, grants and contracts with universities, intramural R&D conducted at government labs, and R&D contracts with private/public consortia.

[6] Other ongoing programs in North Carolina that are relevant to this option include the Industrial Extension Service (IES) at North Carolina State University (NCSU), energy and water efficiency programs at the Division of Pollution Prevention and Environmental Assistance (DPPEA), Western Waste Reduction Partners (WRP) and other similar programs. The North Carolina State Energy Office also offers a number of programs in many sectors. See also http://www.seea.us/PDFs/SEEA DSM.pdf

[7] See http://www.eflhome.com/

[8] See Docket No. E-100, Sub 83.

[9] See Docket No. E-100, Sub 101.

market-rate home construction, and provides energy efficiency assistance to North Carolina industry.[10]

- The SEO is involved in federal Industries of the Future. The Clean Smokestacks Act of 2002 (CSA) recommendation A-5: Promote and Support Efforts to Establish North Carolina as a World Leader in GHG, Non-Carbon Fuels and Energy Efficiency Technologies SEP promotes further incentives for high-efficiency motors.
- **SEO Contract, Energy Management Program,** operated in conjunction with the North Carolina State University (NCSU) Industrial Extension Service.
- **SEO Contract, The Center for Energy Research and Technology.**
- **SEO Contract, Energy Efficiency for Nonprofits.**
- **SEO Contract, ElectriCities—Energy Auditor.**
- **SEO Contract, Energy Efficiency Field Assistance Waste Reduction Partners.**
- **SEO Contract, Central and Eastern Waste Reduction Partners.**
- **SEP 7-4:** Develop performance contracting procedures and other ways to finance energy efficiency projects for state and local governments, university and public school systems, and public housing.
- Duke Power has a special needs low-interest loan program for low-income residents for HVAC equipment and weatherization measures.

Type(s) of GHG Reductions

Principally, the reduction in GHG emissions (largely carbon dioxide [CO_2]) from avoided electricity production and avoided on-site fuel combustion. Less significant are the reduction in methane (CH_4) emissions from avoided fuel combustion and avoided pipeline leakage. Other GHG impacts are also conceivable, but are likely to be small (black carbon, nitrous oxide [N_2O]) and/or very difficult to estimate (materials use, life cycle, market leakage, etc.).

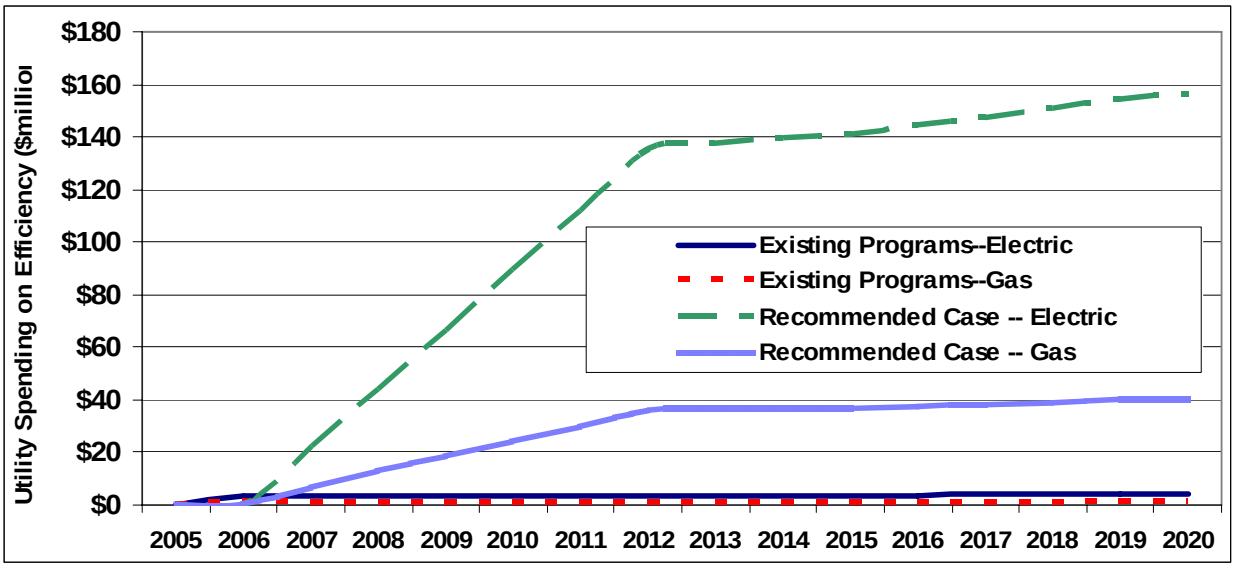
Estimated GHG Reductions and Costs (or Cost Savings)

The table below shows the incremental savings of this option over and above any savings that are expected to accrue from current utility DSM programs in North Carolina. Figure E-1 compares the overall utility revenues devoted to energy efficiency programs under the RCI-1 option as analyzed (at spending levels required to offset growth in emissions). Please see Annex B to these descriptions for additional details of the analysis of this option.

[10] See http://www.advancedenergy.org/

Demand-Side Management Programs for the Residential, Commercial and Industrial Sectors	2010	2020	Units
Recommended Case: "Top-ten States" Energy Efficiency (EE) Investment			
GHG Emission Savings	1.9	11.6	$MMtCO_2e$
Net Present Value (2007–2020)		–$1,895	$million
Cumulative Emissions Reductions (2007–2020)		77.1	$MMtCO_2e$
Cost-Effectiveness		–$25	$/tCO_2e$

Figure E-1. Comparison of overall utility revenues devoted to energy efficiency programs under RCI-1



Data Sources: Costs of DSM programs from a rough average of compilations of program experience for Northwest utilities and estimates for an energy efficiency program as part of a renewable portfolio standard in North Carolina[11] (electric) and from utility programs nationwide (gas).

Quantification Methods: The CAPAG suggests reviewing the interplay of approaches in RCI-1 through RCI-3 when analyzing these options.

Key Assumptions: Sufficient energy efficiency opportunities are available and achievable to offset growth in utility sales. Baseline growth in electricity sales are as included in the Inventory and Forecast prepared for the CAPAG.[12] Transmission and Distribution loss fractions are assumed to start at 6.3% of generation in 2006, and falling to 5.6% of generation by 2020. These

[11] GDS Associates, Inc. Report for the NCUC, *A Study of the Feasibility of Energy Efficiency as an Eligible Resource as Part of a Renewable Portfolio Standard for the State of North Carolina,* December 2006.

[12] At the January 24 CAPAG meeting, a CAPAG member expressed doubts that sufficient generation and/or imports would be available in North Carolina to meet the future levels of electricity demand included in the baseline forecast.

values are consistent with those used for evaluation of energy supply options related to the electricity sector.

Key Uncertainties

- North Carolina-specific costs of DSM programs at savings levels modeled.
- Levels of spending/savings from existing DSM programs in North Carolina.
- Impact of electricity energy efficiency programs on peak demand as well as energy requirements.[13]

Additional Benefits and Costs

Benefits

- Reducing use of electricity and natural gas through this option also reduces emissions of local and regional air pollutants, such as sulfur and nitrogen oxides, which in turn reduce the human health and other impacts of those emissions.[14]
- Co-benefits include transmission/distribution system costs reduction

Costs

None cited.

Feasibility Issues

- Costs and performance vary substantially between measures that might be considered for DSM programs. Some measures may present low capital costs and higher operating costs (or vice versa), and there is uncertainty about the costs and savings for other measures.
- Interaction with appliance standards and utility programs.

Status of Group Approval

Completed.

Level of Group Support

Unanimous consent.

Barriers to Consensus

None.

[13] TWG members requested estimates of the impacts of RCI-1 and other options on peak power demand as well as on electric energy requirements. The magnitude of changes to peak power demand could affect both avoided costs and avoided GHG emissions associated with energy efficiency actions.

[14] Tools such as the EPA's COBRA (Co-benefits Risk Assessment Model) and BenMAP (Environmental Benefits Mapping and Analysis Program) can be used to obtain estimates for the economic benefits of reduction of non-GHG air pollutant emissions that accompany GHG emissions reduction.

RCI-2. Expand Energy Efficiency Funds

Mitigation Option Description

The public benefits charge (sometimes call systems benefits charge) is a fee assessed to utility customers based on their usage of energy in a given time period. With deregulation in many states, the utility commissions often lose the ability to require the electric utilities to have efficiency programs. The result in many states is the development of the public benefits charge, which is a non-bypassable charge on electric bills. The funds collected are then provided to a third party to provide energy efficiency programming.

Mitigation Option Design

It is recommended that North Carolina's existing Public Benefits Charge be significantly increased to support more investments in energy efficiency and renewable energy options. While the State has a well-established public benefits charge and fund, the charge to consumers has not changed since its inception in 1980. Since that time, other states have implemented public benefits charges that are significantly higher than in North Carolina. If North Carolina were to raise its public benefits charge to the level of the national average collected by other states, funds collected would be more than 20 times higher. The increased charge in other states has allowed them to take the lead and drive energy efficiency both locally and nationally.[15]

It is recommended that these increased public benefits charges be collected under the oversight of the NCUC, and invested in residential, commercial, and industrial energy efficiency and renewable energy programs through one or more third-party administrators. Long-term consistency in management and dedicated application of funds collected via public benefits charges to the target programs will be crucial to the success of this initiative.

Investments in energy efficiency and renewable energy made using public benefits funds would be expected to span a wide variety of residential, commercial and industrial applications.[16]

Goals: Reduce GHG emissions from RCI activities by providing public benefit charges adequate to implement energy efficiency and renewable energy programs comparable to the more effective public benefits charge-funded programs in the United States. Information from a national compilation on existing and planned electric utility spending on energy efficiency programs in other states was reviewed, and indicated spending in the range from a fraction of

[15] Because almost all public benefit charges are currently assessed in cold weather states, the majority of research and program development has been directed to issues faced in the Northeast and Northwest. While some of these programs can be translated to North Carolina, many cannot, due to differing electric rates and climates. Unfortunately, there are no substantial public benefits programs in the Southeast, leaving the area shallow in terms of energy efficiency programs at a time when population growth is pushing electric demand to new highs.

[16] Applications could include (but would by no means be limited to) measures such as solar-powered (absorption) air conditioning, ground-source heat pumps, and efficiency improvement programs for window air conditioning units, lighting, water heating, plug loads, networked personal computer management, power supplies, motors, pumps, boilers, and other appliances and equipment.

one percent to approximately three percent of utility revenues. On that basis, 1% of utility revenues was chosen as an appropriate public benefits charge goal for North Carolina at present.

Timing: Three-year phase-in of public benefits charges from the current level to a level consistent with the goals above.[17]

Parties Involved: The public benefits charge is collected from customers of all gas and electric utilities. The collected Public Benefits Fund (PBF) is then spent on energy efficiency and renewable energy investments in all sectors. All relevant stakeholder groups are involved in the design, governance and oversight, management, and implementation of programs to invest these funds.

Implementation Mechanisms

As stated above, we believe the most effective implementation method is to work through the NCUC to increase funding in the established program. While funding will increase, funding allocations do not have to stay the same.

Potential implementation mechanisms and supporting activities for this mitigation option include

- Provision of programs with substantial incentives for consumers to participate, and that include retailer training, marketing and promotion, education, and other elements designed to ensure program effectiveness.
- Funding of R&D for Energy Efficiency, Renewable Energy, and Other GHG Reduction Strategies. Funding from the Public Benefits Charge can in part be used for R&D contracts with private firms, grants and contracts with universities, intramural R&D conducted at government labs, and/or R&D contracts with private/public consortia.
- Performance-based Contracting for funding of energy efficiency improvements, with capital costs paid back through energy savings.
- Establishment of a Reinvestment Fund providing financing for energy-efficiency and other GHG emissions-reduction efforts. This fund would be used in part to create infrastructure to deliver energy-efficiency and renewable technologies. Allowing state agencies to keep the net savings from energy efficiency actions undertaken with the use of public benefits funds, or to reinvest savings in energy-efficiency or other projects, will be crucial to the success of fund initiatives in the public sector. The Reinvestment Fund can take the form of a Special capital fund for businesses developing renewable energy sources, such as the Pennsylvania "Energy Harvest" program.

Related Policies/Programs in Place

- North Carolina has the oldest public benefits charge program, established in 1980 by the NCUC. The original intent of this program was to reduce electric demand in an effort to slow the need for new power plant construction. The current public benefits charge of 0.003567

[17] In other states, a dramatic increase in public benefits funding levels has led to severe growing pains as administration of such funding was difficult to develop. A 3-year plan of implementation can allow expectations to be more effectively set and realized.

cents per kWh translates to approximately three cents per month per average residential customer in the State. The total collected amounts to about $3.5 million per year. These funds are used for energy efficiency and economic development programs throughout the state. Because of the small amount of funding, efforts have been specialized to serve specific markets in the state. Industrial motors and process heating receive much of the attention in an effort to make our industries more efficient and competitive, thereby retaining and building the job base. The other primary area of funding is the residential new construction sector.

- CSA recommendation LT-5, *Develop a Public Benefits Fund.*
- NCUC is presently investigating several issues involving DSM and Energy Efficiency in the current Integrated Resource Planning.[18] This investigation includes Public Benefit Funds.
- In 1980 the NCUC established a systems benefit charge, creating a nonprofit corporation to administer the funds with the charter "to encourage energy efficient economic development in North Carolina." The nonprofit Advanced Energy operates programs for subsidized and market-rate home construction, and provides energy efficiency assistance to North Carolina industry.[19]
- It was noted during the May 23 CAPAG meeting that the NC Tax Credit for Renewable Technology Investment has "sunseted" (lapsed), and should be brought back (or replaced with a program with similar goals).
- **SEP Exec-8:** Reexamine existing legislation and regulations as pertains to barriers and strategies to develop wind energy while still protecting North Carolina's natural beauty.
- **SEP Exec-9:** Incentives and regulatory or administrative measures for development of renewable electricity generation facilities, solar water heating, passive and active solar space heating, and daylighting.
- **SEP Exec-13:** Facilitate efforts of local governments to finance energy efficiency and renewable energy projects.
- **SEP 4-1:** The NCUC is encouraged to promote policies that create diversity in energy supply such as natural gas, solar energy, wind energy, biomass, and hydrogen from renewable sources with particular emphasis on in-state energy development.
- **SEP 7-4:** Development of performance contracting procedures and other ways to finance energy efficiency projects for state and local governments, university and public school systems, and public housing.
- **SEP 8-6:** Continue its work to formulate and advance mortgage-based incentives for high performance new homes.
- **SEP 9-2:** Promotion and development of guidelines for performance contracts, conduct workshops, and provide technical assistance on developing performance contracting documents.

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[18] See in Docket No. E-100, Sub 110.

[19] See http://www.advancedenergy.org/(6.9)

Type(s) of GHG Reductions

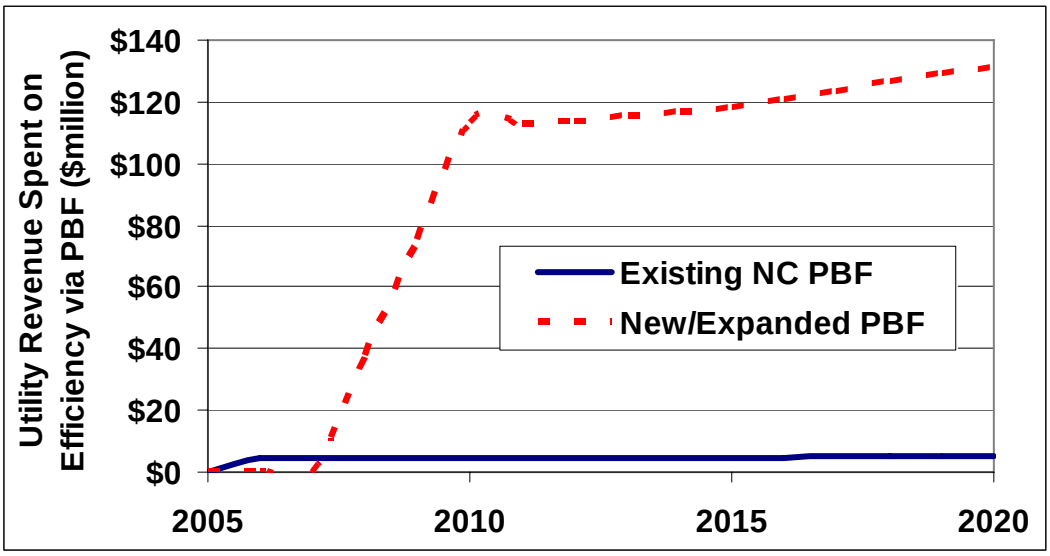
As with RCI-1, this option would principally yield reductions in GHG emissions (largely CO_2) from avoided electricity production and avoided on-site fuel combustion. Less significant are the reduction in CH_4 emissions from avoided fuel combustion and avoided pipeline leakage. Other GHG impacts are also conceivable, but are likely to be small (black carbon, N_2O) and/or very difficult to estimate (materials use, life cycle, market leakage, etc.).

Estimated GHG Reductions and Costs (or Cost Savings)

The table below shows the incremental savings of this option over and above any savings that are expected to accrue from the current public benefits program in North Carolina. Figure E-2 compares the overall utility revenues devoted to public benefits under the RCI-2 option as analyzed. Please see Annex B under these descriptions for additional details of the analysis of this option.

Expand Energy Efficiency Funds	2010	2020	Units
GHG Emission Savings	1.5	8.0	$MMtCO_2e$
Net Present Value (2007–2020)		–$1,346	$million
Cumulative Emissions Reductions (2007–2020)		54.8	$MMtCO_2e$
Cost-Effectiveness		–$25	$/tCO_2e$

Figure E-2. Comparison of overall utility revenues devoted to public benefits under RCI-2



PBF = Public Benefits Fund

Data Sources: Costs of DSM programs from a rough average of compilations of program experience for Northwest utilities and estimates for an energy efficiency program as part of a

renewable portfolio standard in North Carolina[20] (electric) and from utility programs nationwide (gas).

Quantification Methods: The CAPAG suggests reviewing the interplay of approaches in RCI-1 through RCI-3 when analyzing these options.

Key Assumptions: 1% of utility electric and gas revenues are spent annually on public benefits programs (assumed mostly energy efficiency).

Key Uncertainties

- North Carolina–specific costs of energy efficiency investments at savings levels modeled.
- Future expected levels of spending vs. savings from public benefits charge program in North Carolina

Additional Benefits and Costs

Benefits

- Co-benefits could include transmission/distribution system costs reduction.
- Would help to provide local employment and grow renewable energy use.

Costs

None cited.

Feasibility Issues

- Costs for this option are uncertain, depending on measures included.
- Interaction with appliance standards and utility programs needs to be taken into account.

Status of Group Approval

Completed.

Level of Group Support

Unanimous consent.

Barriers to Consensus

None.

[20] GDS Associates, Inc. Report for the NCUC, *A Study of the Feasibility of Energy Efficiency as an Eligible Resource as Part of a Renewable Portfolio Standard for the State of North Carolina,* December 2006.

RCI-3. Energy Efficiency Requirements for Government Buildings

Mitigation Option Description

Recognizing that governments should "lead by example" the option presented here provides energy use targets to improve the efficiency of energy use in State and local government buildings. This option sets energy-efficiency goals for the existing government building stock, as well as for new construction and major renovations of government buildings.

Mitigation Option Design

Elements of this Option Design include the following:

- Adherence by new and renovated government buildings to the energy-related guidelines included in LEED+ (Leadership in Energy and Environmental Design), a national building certification program that currently exists in the commercial building arena but would have more explicit energy efficiency requirements than LEED alone. Conversion of existing buildings to bring them into compliance with the LEED+ standard.
- Revision of the existing policy(s) that separates construction budgets from maintenance budgets. By linking these, the increased energy efficient construction or alterations will be seen as long term savings.
- Extension of green campus initiatives to all public academic and government campuses.
- Energy benchmarking, measurement, and tracking programs for municipal and state buildings.
- Energy efficiency requirements for new, renovated, and existing government buildings.
- Renewable energy requirements for new, renovated, and existing government buildings.

Goals: New construction and major renovations of government buildings must meet LEED+ requirements. Commence with all buildings entering the design phase by 2010. Based on a state composite average, achieve a 20% reduction from a baseline fiscal year of 2002–03 in energy consumption per gross square foot per year for the entire North Carolina government existing building stock by 2027. In the last year of the program, establish a new 5-year goal for government building energy efficiency improvement.

Timing: See the timing targets described in the "goals" section above. This option will build on the USI (Utility Savings Initiative) program already in place at the North Carolina SEO.

Parties Involved: State agencies, University of North Carolina (UNC) System and affiliates, Community College System and K-12 school districts, local governments and other public entities, building code enforcement, architects, building designers, engineers, developers, builders, contractors, regulators—State Construction Office, SEO, Office of State Budget and Management.

Implementation Mechanisms

Potential implementation mechanisms and supporting activities for this mitigation option include

- Performance-based contracting (PC) for funding of energy efficiency improvements; capital costs paid back through energy savings. Should the PC reach a payback period threshold in perhaps 12 or 15 years, or mandate PC contain a renewable energy component, then funds are paid back.
- Create a clearinghouse for information on and access to software tools to calculate impact of energy efficiency and renewable technologies for buildings.
- Energy technologies that should be promoted by this section include but are not limited to
  - Active and passive solar building technologies such as photovoltaic panels, solar hot water heaters, and solar-powered (absorption) air conditioning.
  - Support for new-to-market technologies, such as solar hybrid lighting (using light guides to bring daylight into building interiors), where appropriate in select, potentially high profile, researched and monitored projects for future broad application.
  - Ground-source heat pumps.
  - Focus on specific end uses/technologies such as lighting, water heating, plug loads, networked computer management, power supplies, motors, pumps, boilers, and cool roofing.
- Carry out a comprehensive statewide survey of energy and water efficiency features in existing government buildings to provide information on the potential for energy efficiency in the NC government building stock.

Related Policies/Programs in Place

- The Environments for Living program[21] is an example of the types of improvements included in this option, with builders having built 80,000 homes in the South and Southwest under the program in the last 5 years. Also, solar water heating is included in the NC Green Power Program.
- The NC HealthyBuilt Homes (HBH) program, supported in part by the NC SEO, has been very active in the State.
- ENERGY STAR Homes is another example of building performance standards and certifications in use in North Carolina.
- The SEO is involved in federal Industries of the Future. CSA recommendation A-5: "Promote and Support Efforts to Establish North Carolina as a World Leader in GHG, Non-Carbon Fuels and Energy Efficiency Technologies."
- **SEP Exec-11:** Reduction of energy consumption in State agencies and universities.
- **SEP Exec-15:** The General Assembly should review options, such as a Public Benefits Fund (PBF) or other means, to enable funding of the recommendations in the State Energy Plan.

[21] See http://www.eflhome.com/

- **SEP Exec-20:** The SEO should organize a statewide effort to develop criteria for a residential high performance building program to reduce the life cycle cost of new and existing buildings.
- **SEP 6-1:** Development of a Solar Schools Program.
- **SEP 7-1:** North Carolina statutes should require that designers of all new public buildings provide estimates of projected energy consumption and energy costs for the building prior to construction.
- **SEP 7-3:** Implementation of high performance building guidelines developed for North Carolina in all new public buildings and for new public housing.
- **SEP 7-7:** Local governments should be encouraged to implement SEP recommendations and other energy efficiency programs.
- **SEP 8-3:** The SEO should encourage new manufactured homes to comply with the critical components of the state energy code for site-built residential units and promote ENERGY STAR manufactured homes.
- **SEP 9-4:** The SEO should promote the use of and provide training for commercial building energy analysis software.

Type(s) of GHG Reductions

As with RCI-1 and RCI-2, this option would principally yield reductions in GHG emissions (largely CO_2) from avoided electricity production and avoided on-site fuel combustion. Less significant are the reduction in CH_4 emissions from avoided fuel combustion and avoided pipeline leakage. Other GHG impacts are also conceivable, but are likely to be small (black carbon, N_2O) and/or very difficult to estimate (e.g., materials use, life cycle, market leakage).

Estimated GHG Reductions and Costs (or Cost Savings)

Energy Efficiency Requirements for Government Buildings	2010	2020	Units
GHG Emission Savings	0.0	1.1	$MMtCO_2e$
Net Present Value (2007–2020)		–$88	$million
Cumulative Emissions Reductions (2007–2020)		6.4	$MMtCO_2e$
Cost-Effectiveness		–$14	$/tCO_2e$

Data Sources: Costs of energy efficiency improvements based on studies of costs of building improvements and code changes.

Quantification Methods: Estimates fractional savings in energy intensities needed, after code improvements, in new and existing government buildings. Allocates intensity savings among energy efficiency, renewable energy sources.

Key Assumptions: Fractions of electric and gas intensity improvement accounted for by efficiency improvements, solar thermal, solar photovoltaics (PV), and/or increased biomass use; fractional savings target of 20% over new code levels.

Key Uncertainties

- Total government building space in North Carolina (regional estimates currently used with state building floor area data to estimate total government building floorspace—state, local, county, and schools).[22]
- Fraction of government agencies occupying leased space in North Carolina (estimate of 10% of government-owned building space used).
- Rate of building renovations versus new construction in the government sector (estimate of 30% used based on consideration several national and regional sources).

Additional Benefits and Costs

Benefits

Co-benefits could include transmission/distribution system costs reduction.

Costs

None cited.

Feasibility Issues

- Costs for this option are uncertain, depending on the measures included.
- Potential interaction with appliance standards and utility programs.

Status of Group Approval

Completed.

Level of Group Support

Unanimous consent.

Barriers to Consensus

None.

[22] Data compiled from NC State Property Office indicates total gross floor area of state-owned buildings in North Carolina of approximately 106 million square feet as of 2006. Summary data provided by Len Hoey of the NC State Energy Office.

RCI-4. Market Transformation and Technology Development Programs

Mitigation Option Description

A market transformation program is designed to create a situation where the bulk of the private market automatically adopts or incorporates technologies or techniques that result in improved energy efficiency. The goal of a market transformation and technology development program is to put energy efficiency technologies and practices into a position where they will be demanded by the public and chosen by builders and manufacturers. Methods of transformation will be different for each technology or technique, but often revolve around public and private review of quality and effectiveness, including partnerships between government agencies, retailers, manufacturers, and non-governmental agencies.

Mitigation Option Design

The intent of a market transformation program is to ensure that voluntary standards are rigorous enough to set a high bar while being understandable and valuable to the buyer. Market transformation efforts also often go hand-in-hand with technology development efforts.

A market transformation and technology development program must be long-term and robust. There must be *consistent* and enduring support for technology improvement and incorporation. There must be continued investment in technology development and integration. There must be independent evaluation of the efficacy of the technologies.

This particular recommendation is broadly defined and does not address a single technology or market. Rather, it addresses a method for bringing appropriate technologies and processes to the marketplace. Defined as such, it is recommended that several technologies be included in market transformation strategies for North Carolina, though others can and should be included as well.

- Promote the appropriate use of National Electrical Manufacturers Association (NEMA) Premium motors and drives in industrial applications.
- Provide support for implementation of renewable energy applications such as solar water heaters.
- Target the early retirement of older appliances using a “bounty” program.
- Provide support for processes that recover waste heat from industrial applications.
- Promote the use of ground-source heat pumps by helping to identify and qualify appropriate applications.
- Encourage increased funding for ENERGY STAR to identify and qualify a greater number of products under their labeling.
- Encourage and enable smaller purchasers to act in aggregate groups to reduce costs and quantify emission reduction benefits from technology and process improvements.

- Provide a continuous funding level for near-term research and deployment of energy efficient technologies and processes.

Goals: Because this recommendation involves policy process rather than a specific emissions reduction technology, the goals will be different and dependent on the selected technologies included in the programs. A goal of any policy in this area is to provide consistent support with the end-result being a time when the support can be removed without the program benefits ending as well. Thus, the goal is to permanently transform markets to increase and accelerate the uptake of products with higher energy efficiency and of renewable energy products, working through a regional alliance that achieves savings similar to those achieved in other regions of the United States.

Timing: This mitigation option recommendation requires consistent and long-term thinking. Successful examples of transformation programs in other areas of the country were years and decades in the making. Set up agency/agencies in 2010. Start activities in 2012.

Parties Involved: All sectors and stakeholders in the state may be involved in market transformation programs, including retailers, utilities, manufacturers, nonprofit consortia, consumers associations, professional associations (engineers, builders, architects, designers), and state agencies.

Implementation Mechanisms

Implementation of market transformation programs requires the participation and buy-in of industry partners, regulatory bodies and consumer groups. Potential implementation mechanisms and supporting activities for this mitigation option include

- Collaborative marketing of energy efficiency and renewable energy technologies.
- Specific implementation measures mentioned as possible for this option include tax credits, low/no interest loans, and similar financial incentives to business, industries and commercial firms to upgrade their equipment (including manufacturing and pollution control equipment) to more energy-efficient technologies. The latter approach is especially important for small manufacturers, and can mean access to micro-loans.
- Funding of R&D for Energy Efficiency, Renewable Energy, other GHG Reduction Strategies.
- Could include patent protection, R&D tax credits, production subsidies or tax credits to firms bringing new technologies to market, tax credits or rebates for new technology buyers, government procurement, and demonstration projects.
- Market transformation is an area where the SEO might be funded to contribute.

Related Policies/Programs in Place

- There are several related programs in place that can be modeled for other technologies and processes. One such program is run by the North Carolina Housing Finance Agency (NCHFA). The NCHFA provides training to their nonprofit builders such as Habitat for Humanity affiliates. Further, the NCHFA provides a program where organizations may receive funds to participate in an energy guarantee program for new homes, if the homes are

tested and achieve certain performance levels. More than 1,000 homes in North Carolina are part of this program, which is now being replicated in other states.

- **SEO Contract Appalachian State University Energy Center.**
- A program exists in North Carolina to dispose of a refrigerator for free.
- **SEP Exec-1:** The North Carolina Department of Commerce 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.
- In 1980 the NCUC established a systems benefit charge, creating a nonprofit corporate to administer the funds with the charter "to encourage energy efficient economic development in North Carolina." The nonprofit Advanced Energy operates programs for subsidized and market-rate home construction, and provides energy efficiency assistance to North Carolina industry.[23]
- SEO is involved in federal Industries of the Future. CSA recommendation A-5: Promote and Support Efforts to Establish North Carolina as a World Leader in GHG, Non-Carbon Fuels and Energy Efficiency Technologies. SEP recommends further incentives for high-efficiency motors.
- **SEO Contract PEM Fuel Cell.**
- **SEO Contract Landfill Gas Conference.**
- Energy Improvement Loan Program.
- NC Weatherization Assistance Program, for low income earners; SEP recommends extending weatherization.

Type(s) of GHG Reductions

GHG impacts are similar in nature to those noted for RCI-1 through RCI-3 above.

Estimated GHG Reductions and Costs (or Cost Savings)

Energy Efficiency Requirements for Government Buildings	2010	2020	Units
GHG Emission Savings	0.0	2.0	$MMtCO_2e$
Net Present Value (2007–2020)		–$339	$million
Cumulative Emissions Reductions (2007–2020)		10.5	$MMtCO_2e$
Cost-Effectiveness		–$32	$/tCO_2e$

Data Sources: Market transformation program costs and performance based on programs and experience of the Northwest Energy Efficiency Alliance.

Quantification Methods: Apply program results in percent savings, from other regions, to North Carolina.

[23] See http://www.advancedenergy.org/

Key Assumptions:

- Market transformation programs can reduce electricity demand by 0.2% annually.
- The implementation must be timed correctly.

Key Uncertainties

It is unknown the degree to which other states in the region will join with North Carolina to increase program effectiveness.

Additional Benefits and Costs

Benefits

- The non-energy and non-emission benefits are almost always going to be the economic drivers behind the success of these programs. Focusing only on emission reductions or only on payback through energy efficiency of the user will eliminate many technologies when they could otherwise provide substantial economic benefits. An example is an improvement to an industrial production line that may have negligible overall energy consumption reduction at the plant, but that decreases the energy consumption per unit produced (energy intensity) while speeding up production and retaining jobs in the state.
- Co-benefits could include transmission/distribution system costs reduction.
- Programs could help to lower capital and installation costs.

Costs

None cited.

Feasibility Issues

Interaction with appliance standards and utility programs.

Status of Group Approval

Completed.

Level of Group Support

Unanimous consent.

Barriers to Consensus

None.

RCI-5. Improved Appliance and Equipment Efficiency Standards

Mitigation Option Description

Appliance efficiency standards reduce the market cost of energy efficiency improvements by incorporating technological advances into base appliance models, thereby creating economies of scale. Appliance efficiency standards can be implemented at the state level for appliances not covered by federal standards, or standards can be jointly developed by multiple states.

Mitigation Option Design

This mitigation option involves the replication of standards adopted in other states for appliances not covered by federal standards. It also involves the State, working together with other states in the region, advocating for stronger federal appliance efficiency standards where this is technically feasible and economically justified. Of these options for coverage, implementation of stronger-than-federal standards together with other states, including states in the Southeast region, is much preferred by the CAPAG, as it provides a broader market for manufacturers and thus lowers net costs of higher-efficiency devices to North Carolina consumers.

Elements of this option design include

- Development of committee or other working group to develop recommendations on appliance standards (similar to existing group for building codes).
- Adoption of State-level Appliance Efficiency Standards, defined sufficiently broad enough to include, for example, commercial sector, and information technology (IT) equipment.
- Support from North Carolina for adoption of more stringent federal-level appliance efficiency standards.
- Design of a standard for recycling of materials in appliances.
- Inclusion of water use reduction as a criterion for appliance efficiency improvement.

Goals: Increase stringency of appliance standards to the level of those recommended by the Appliance Standards Awareness Program.[24]

Timing: Adopt new standards by 2010. Standards in force by 2012.

Parties Involved: State agencies to enforce state codes and standards.

[24] See www.standardsasap.org. The analysis recommends standards for the following products: bottle-type water dispensers, commercial boilers, commercial hot food holding containers, compact audio products, DVD (digital versatile/digital video disc) players and recorders, liquid immersion distribution transformers, medium voltage dry-type distribution transformers, metal halide lamp fixtures, pool heaters, portable electric spas, residential furnaces and boilers, residential pool pumps, single voltage external AC to DC (alternating current to direct current) power supplies, state-regulated incandescent reflector lamps, walk-in refrigerators and freezers.

Implementation Mechanisms

Potential implementation mechanisms and supporting activities for this mitigation option include

- Appliance Standards promulgated by legislation or developed administratively.
- Assistance programs to help low-income consumers with purchase of appliances meeting more stringent standards, so as to reduce the higher-first-cost burden of higher-efficiency appliances on those consumers.
- Elevated energy standards for appliances and equipment purchased by public agencies.
- Work with manufacturers and consider impacts on manufacturers when setting new standards.

Related Policies/Programs in Place

- **SEP** recommends ENERGY STAR from 2008 on.
  - The state is an ENERGY STAR Partner.
- Existing Federal Appliance Efficiency Standards (2005 Energy Bill).
- **SEP 7-6:** North Carolina Department of Administration should require that all state facilities with motors larger than 5 horsepower must develop a motor maintenance program.
- **SEP 10-3:** North Carolina should evaluate whether facilities that repair or rewind motors should be certified or otherwise meet a state efficiency requirement.
- **SEP 10-5:** North Carolina should create investment tax credits and other incentives for new and/or retrofitted manufacturing equipment to encourage modernization and efficiency improvements.
- **SEP 10-9:** The SEO should sponsor workshops on industrial energy efficiency around the state directed at industrial facility operators, design and process engineers, and owners.

Type(s) of GHG Reductions

GHG impacts are similar in nature to those noted for RCI-1 through RCI-3 above.

Estimated GHG Reductions and Costs (or Cost Savings)

Improved Appliance and Equipment Efficiency Standards	2010	2020	Units
GHG Emission Savings	0.0	1.0	$MMtCO_2e$
Net Present Value (2007–2020)		–$336	$million
Cumulative Emissions Reductions (2007–2020)		5.3	$MMtCO_2e$
Cost-Effectiveness		–$63	$/tCO_2e$

Data Sources: Fractional savings and costs drawn from the Appliance Standards Awareness Project (ASAP) and the American Council for an Energy-Efficient Economy (ACEEE), 2006. "Leading the Way: Continued Opportunities for New State Appliance and Equipment Efficiency Standards."

Quantification Methods: Results for North Carolina from report above adapted by adjusting for different analysis period, discount rate, and energy prices.

Key Assumptions: Costs and savings from efficiency improvement via standards will be similar in North Carolina to those indicated in the ASAP/ACEEE report.

Key Uncertainties

It is unknown the degree to which other states in the region will join with North Carolina in setting higher-than-federal standards so as to increase effectiveness and practical application of standards.

Additional Benefits and Costs

Benefits

Reduction in water use for some appliance upgrades.

Costs

None cited.

Feasibility Issues

Feasibility enhanced by ongoing efforts in nearby states.

Status of Group Approval

Completed.

Level of Group Support

Unanimous consent.

Barriers to Consensus

None.

RCI-6. Building Energy Codes

Mitigation Option Description

Building energy codes specify minimum energy efficiency requirements for new buildings or for existing buildings undergoing a major renovation. As energy use in buildings in North Carolina accounts for about one-third of North Carolina's current gross GHG emissions, amending State and/or Local Building Codes to make the requirements for minimum energy efficiency levels in buildings more stringent will have a considerable immediate and ongoing impact in reducing building-sector GHG emissions.

Mitigation Option Design

North Carolina has building energy codes modeled on the International Energy Conservation Code 2000 for residential and commercial buildings, and enforced by the Building Code Council. An ongoing process of code amendments for new and renovated residential and commercial buildings is proposed as follows.

- North Carolina should adopt more stringent building codes to improve the efficiency of energy use in buildings. North Carolina can use cost-effectiveness tests to identify where moving beyond national building codes makes economic sense. Also, the state can make improvements in codes including but not limited to HVAC systems, daylighting design to reduce lighting needs, electric lighting design, building envelope design, and using integrated building design strategies.
- North Carolina should move toward adopting innovative features of advanced codes being implemented in other states, such as lighting efficiency requirements in new homes that go beyond the codes in force, as appropriate to conditions in the State.
- Statewide enforcement of both existing and new building codes should be improved at all levels, and enforcement should be fully implemented within 6 months of statewide code adoption (if applicable).
- North Carolina should regularly update its energy codes. A 3-year cycle could be timed to coincide with the release of national model codes.
- As appropriate, codes should be modified to remove obstacles to renewable energy use, daylighting and non-conventional energy-efficient building materials in buildings where applicable.
- Include programs of education for building inspectors and other building industry professionals to assure that the new codes are implemented and enforced.

Goals:

- Enforce existing building energy codes by 2008.
- Establish a new energy code by 2010 that requires new North Carolina residences and commercial/industrial buildings to be 20% more efficient than buildings meeting current national building energy codes, and assure that the new code is enforced.

Timing: Updated every 6 months when the national energy code changes.

Parties Involved: North Carolina Department of Insurance (which can implement new codes), state and local government building code enforcement agencies, Mobile Home Manufacturing Industry and Building Industry Associations.

Implementation Mechanisms

Potential implementation mechanisms and supporting activities for this mitigation option include

- Coordination with consumer products programs, possibly including incentives, retailer training, marketing and promotion, education, etc.
- Develop Training and Education programs for
  - Builders and contractors (related to HVAC sizing, duct sealing, energy analysis program, construction and demolition [C&D] waste recycling, renewable energy system installation, and water distribution systems).
  - Trade school and community college students (for example, including the skills noted above skills in curricula).
  - Building code and other officials in energy code enforcement.
- Develop a clearinghouse for information on and access to software tools to calculate the impacts of energy efficiency and solar technologies for buildings.

Related Policies/Programs in Place

- North Carolina has building energy codes modeled on the International Energy Conservation Code 2003 for residential and commercial and enforced by Building Code Council; SEP R-4 recommends reviewing compliance and potential improvement. Analyses of building code improvements have been undertaken by Jeff Tiller at Appalachian State University (ASU). Building codes are enforced by the Building Code Council and the North Carolina Department of Insurance.
- Latest information on Department of Insurance Web site indicates American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) 90.1 2004.
- Advanced Energy Corporation, NC Solar Center, and others have ongoing programs in this and similar areas.
- Training of Building Code and other Officials in Energy Code Enforcement (Recommended in State Energy Plan).
- Advanced Energy Corporation is currently reviewing nine calculators for assessing building energy efficiency and solar technologies for buildings. Availability of tools could be widened.
- In 1980 the NCUC established a systems benefit charge, creating a nonprofit corporation to administer the funds with the charter "to encourage energy efficient economic development in North Carolina." The nonprofit Advanced Energy operates programs for subsidized and

market-rate home construction, and provides energy efficiency assistance to North Carolina industry.[25]

- The SEO is involved in federal Industries of the Future. CSA recommendation A-5: *Promote and Support Efforts to Establish North Carolina as a World Leader in GHG, Non-Carbon Fuels and Energy Efficiency Technologies,* SEP recommends further incentives for high-efficiency motors.
- NC Weatherization Assistance Program, for low income earners SEP recommends extending weatherization.
- **SEP Exec-14:** The SEO should develop programs, in addition to weatherization, to address energy-efficient housing in the low-income sector.
- **SEP Exec-20:** The SEO should organize a statewide effort to develop criteria for a residential high performance building program to reduce the life cycle cost of new and existing buildings.
- **SEP 7-1:** North Carolina statutes should require that designers of all new public buildings provide estimates of projected energy consumption and energy costs for the building prior to construction.
- **SEP 7-3:** The North Carolina Department of Administration should implement high performance building guidelines developed for North Carolina in all new public buildings and new public housing.
- **SEP 8-1:** The SEO should conduct a study on current compliance levels of residential and commercial buildings with the North Carolina state energy code.
- **SEP 8-2:** The SEO should create an Energy Code Enforcement Assistance Program to provide additional energy code enforcement and outreach officials to serve across the state.
- **SEP 8-3:** The SEO should encourage new manufactured homes to comply with the critical components of the state energy code for site-built residential units and promote ENERGY STAR manufactured homes.
- **SEP 8-7:** The SEO should provide training on high performance buildings to building professionals in a number of different classifications.
- **SEP 9-1:** The SEO should work with appropriate state agencies to provide a design review service that focuses on energy-efficient components and holistic, high-performance, design strategies for new commercial buildings.
- **SEP 9-4:** The SEO should promote the use of and provide training for commercial building energy analysis software.
- Integration with Regional Demand Response Initiatives/recommendations is a SEP recommendation.

Type(s) of GHG Reductions

- CO_2 reduction from avoided electricity production and avoided on-site fuel combustion.

[25] See http://www.advancedenergy.org/ (6.9).

- Modest reduction in CH_4 emissions from avoided fuel combustion and avoided natural gas pipeline leakage, relatively small reductions in N_2O, black carbon emissions from avoided fuel consumption.

Estimated GHG Reductions and Costs (or Cost Savings)

Building Energy Codes	2010	2020	Units
GHG Emission Savings	0.5	3.5	$MMtCO_2e$
Net Present Value (2007–2020)		–$400	$million
Cumulative Emissions Reductions (2007–2020)		23.1	$MMtCO_2e$
Cost-Effectiveness		–$17	$/$tCO_2e$

Data Sources: Building Code Assistance Project (BCAP) analyses by state (including North Carolina) to derive base savings.

Quantification Methods: Apply general BCAP method to estimate code savings, but apply 20% target savings figure.

Key Assumptions: Average costs of building code improvements, ratio of gas improvements to electricity improvements.

Key Uncertainties

It is unknown, if renovations will be included in building energy code requirements. In addition, data on the annual amount of commercial and residential renovated floorspace were not found, so an estimate of 0.3 units of renovated commercial floorspace per unit new commercial floorspace (based on national and regional estimates) was used, and renovated residential floorspace was not considered in the analysis.

Additional Benefits and Costs

Benefits

Potential to also yield water savings, comfort/air quality improvements.

Costs

None cited.

Feasibility Issues

Interaction with appliance standards and utility programs.

Status of Group Approval

Completed.

Level of Group Support

Unanimous consent.

Barriers to Consensus

None.

RCI-7. "Beyond Code" Building Design Incentives and Targets, Incorporating Local Building Materials and Advanced Construction

Mitigation Option Description

Energy use in existing buildings and in non-government-funded new buildings must be substantially improved. This mitigation option provides incentives and targets to induce the owners and developers of new and existing non-government buildings to markedly improve the efficiency with which energy and other resources are used in those buildings, along with provisions for raising targets periodically and resources to help achieve the desired building performance. This option includes elements to encourage the improvement and review of energy use goals over time, and to encourage flexibility in contracting arrangements to encourage integrated energy and resource efficient design and construction.

Mitigation Option Design

Elements of this Option Design include the following:

- Promotion and Incentives for "beyond code" construction, using programs of various types for various sectors:
  - It is important to focus programs for building energy efficiency and renewable, clean, safe energy on specific market segments such as existing residential construction (weatherization), new home construction, apartments, low income housing, commercial new construction, commercial renovation construction, and others.
  - Improved design and construction standards and guidelines addressing multiple aspects of resource conservation, with a focus on energy. Examples of such standards include the following:
    - LEED (a national building certification program) which is currently mature in the commercial building arena but which includes fairly minimal energy requirements in its current version. The newer "LEED plus Massachusetts" standard includes more explicit energy efficiency requirements.
    - NC HBH, a statewide residential green building certification program with ENERGY STAR as the energy efficiency base and additional energy requirements for the building envelope/comfort systems/appliances, lighting, and use of renewable energy. This includes indoor air quality (IAQ) requirements to ensure that EE does not jeopardize human health.
    - ENERGY STAR Homes (a standard focused on energy efficiency for the building envelope and comfort systems).
    - Environments for Living (a national residential energy efficiency certification program focused on large builders with some indoor air quality features).
  - Energy technologies that should be promoted by this section include but are not limited to active and passive solar building technologies, photovoltaic panels on new commercial

buildings and many new homes, solar hot water heaters on homes and other buildings,[26] new and existing building energy technologies, such as solar hybrid lighting, where appropriate, particularly in select, potentially high profile, researched and monitored projects for future broad application, solar-powered (absorption) air conditioning for residential and commercial applications, ground-source heat pumps, high-efficiency boilers, and cool roofing.

Energy education should be promoted under this option in coordination with the programs noted in RCI-8. (See Implementation Mechanisms, below.)

Goals:

- Incentives induce 5% of new residential buildings and 2% of new commercial buildings annually to go to "beyond code" energy use levels that improve energy performance over the average new building (that meets the upgraded building code) by 30%. These numbers will, on average, decrease energy use by 30% across the board above the existing building code requirements and encourage significant examples throughout the state of various building types that use 50% or less energy than is supported by the existing building code.[27]
- Incentives are provided to upgrade 20% of existing buildings by 2015 as follows:
  - Residential building energy performance improvements must increase by 15%.
  - Commercial building energy performance improvements must increase by 20%. This increase in efficiency should bring 20% of existing buildings up to the standard of the 2003 International Energy Conservation Code (IECC; the current NC code, not the improved codes).

Timing: Ramp up program starting in 2007 to full effectiveness by 2012, except where noted otherwise.

Parties Involved: State governments, local governments, and other public entities (leading by example, largely via RCI-3); building code enforcement; architects, building designers, engineers, developers, builders, and contractors; retailers of energy-efficient products; manufacturers of alternative building products.

Implementation Mechanisms

Potential implementation mechanisms and supporting activities for this mitigation option include

- Performance-based contracting for funding of energy efficiency improvements, with capital costs paid back through energy savings.

[26] Note that the inclusion of solar technologies here may overlap with programs recommended under other RCI options.

[27] It should be noted that a 30% reduction is cost-effective given basic improvements in design, materials, and equipment but a 50% reduction in energy use requires a much heavier investment cost and will often require the use of renewable energy strategies (depending on building orientation, placement, or exposure). This effort is focused on supporting and growing the market of building professionals in our state who can perform this work for three reasons in addition to decreasing GHG emissions: (1) increase availability of capable building professionals for consumers wishing to increase energy performance, (2) increase market competition in energy performance improvements, and (3) provide a base for energy security as energy resources become more expensive and/or scarce.

- The CAPAG recommends that the TWG suggest potential sources of funds to provide incentives for "green building" design and implementation.
- Streamlined application procedures for green building-related improvements.
- Comprehensive state survey of energy and water efficiency features in existing residential and commercial buildings to provide information on the potential for energy efficiency in North Carolina buildings.
- Implementation of a Clearinghouse for information on and access to software tools to calculate impact of energy efficiency and solar technologies for buildings.
- Energy benchmarking, measurement, and tracking programs for privately-owned buildings.
- Energy education that should be promoted under this option, in coordination with the programs noted in RCI-8 and including but not limited to:
    - Training and Education for building construction phase professionals (e.g., HVAC sizing, duct sealing, energy analysis program, C&D waste recycling, renewable energy system installation, and water distribution systems).
    - Support for growth and health of the residential building performance specialist industry.
    - Continuing Education for building design phase professionals, including architects, engineers, developers, contractors, urban planners, and realtors.
    - Energy efficiency, renewables and related education introduced at community colleges and trade schools.
- Building codes could include a recommendation that existing homes and commercial buildings at resale are upgraded to meet an energy efficiency standard, and financing programs be provided to help with the costs of those upgrades. If implemented, such a recommendation could be formulated so that only cost-effective savings would be included, and coordinated with lender and education consumer programs to spur the offering of "green mortgages" for qualifying properties, and to demonstrate overall lower ongoing cost-of-ownership for upgraded buildings.

Related Policies/Programs in Place

- The Energy Independence Act, S2051 filed May 2006, requires facility projects that receive state funding to reduce energy purchases by 20% by 2015.
- NC Green Building Technology database provides searchable database on case studies.
- S2001, H1272 required state government to review the use of High Performance Building guidelines in 7 buildings.
- Examples of existing programs: NC HBH, Healthy Building Resource Center Environments for Living in addition to those listed, groups offering programs and other services related to building energy efficiency and related programs include the Community Emergency Response Team (CERT) at North Carolina Agricultural and Technical State University (NCA&T), Appalachian State, Southern Research Institute, Research Triangle Institute (RTI), and others.
- SEP recommends:

  - ENERGY STAR home requirements by county.
  - Energy efficient mortgages.
  - Develop further programs to support privately funded projects.
  - Require high performance building standards for permits to build privately funded school projects.
- Advanced Energy Corporation and NC Solar Center, and others have ongoing programs in this and similar areas.
- Advanced Energy Corporation is currently reviewing nine calculators for assessing building energy efficiency and solar technologies for buildings. Availability of tools could be widened.
- At the May 23 CAPAG meeting, the Environments for Living program[28] was noted as an example, with builders having built 80,000 homes in the South and Southwest under the program in the last 5 years. Also, it was noted that solar water heating is included in the NC Green Power Program.
- In 1980 the NCUC established a systems benefit charge, creating a nonprofit corporate to administer the funds with the charter "to encourage energy efficient economic development in North Carolina." The nonprofit Advanced Energy operates programs for subsidized and market-rate home construction, and provides energy efficiency assistance to North Carolina industry.[29]
- The SEO is involved in federal Industries of the Future. CSA recommendation A-5: "Promote and Support Efforts to Establish North Carolina as a World Leader in GHG, Non-Carbon Fuels and Energy Efficiency Technologies." SEP recommends further incentives for high-efficiency motors.
- SEP recommends state procurement of environmentally preferable products.
- NC Weatherization Assistance Program, for low income earners SEP recommends extending weatherization.
- Extend green campus initiatives to all university Buildings is a SEP recommendation.
- Energy benchmarking, measurement, and tracking programs for municipal and state buildings is a SEP recommendation.
- **SEO Contract, The Center for Energy Research and Technology.**
- **SEP Exec-20 (formerly 8-4):** The SEO should organize a statewide effort to develop criteria for a residential high performance building program to reduce the life cycle cost of new and existing buildings.
- **SEP 7-3:** The North Carolina Department of Administration should implement high performance building guidelines developed for North Carolina in all new public buildings and for new public housing.

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[28] See http://www.eflhome.com/

[29] See http://www.advancedenergy.org/

- **SEP 8-3:** At a minimum, the SEO should encourage new manufactured homes to comply with the critical components of the state energy code for site-built residential units and promote ENERGY STAR manufactured homes.
- **SEP 8-5:** The SEO should develop a comprehensive, statewide promotional campaign for high performance buildings.
- **SEP 8-6:** The SEO should continue its work to formulate and advance mortgage-based incentives for high performance new homes.
- **SEP 8-7:** The SEO should provide training on high performance buildings to building professionals in a number of different classifications.
- **SEP 8-8:** The SEO should provide training for building professionals on specific targeted technologies including residential daylighting, solar water heating, heat pump water heaters, new insulation products, and advanced HVAC systems and controls.
- **SEP 9-1:** The SEO should work with appropriate state agencies to provide a design review service that focuses on energy-efficient components and holistic, high-performance, design strategies for new commercial buildings.

Type(s) of GHG Reductions

- CO_2 reduction from avoided electricity production and avoided on-site fuel combustion.
- Modest reduction in CH_4 emissions from avoided fuel combustion and avoided natural gas pipeline leakage, relatively small reductions in N_2O, black carbon emissions from avoided fuel consumption.

Estimated GHG Reductions and Costs (or Cost Savings)

"Beyond Code" Building Design Incentives and Targets, Incorporating Local Building Materials and Advanced Construction	**2010**	**2020**	**Units**
GHG Emission Savings	0.7	5.2	$MMtCO_2e$
Net Present Value (2007–2020)		–$494	$million
Cumulative Emissions Reductions (2007–2020)		34.2	$MMtCO_2e$
Cost-Effectiveness		–$14	$/tCO_2e$

Data Sources: Costs of energy efficiency improvements based on studies of costs of building improvements and code changes.

Quantification Methods: Estimates fractional savings in energy intensities needed to meet targets in new commercial and residential buildings. Allocates intensity savings among energy efficiency, renewable energy sources.

Key Assumptions: Fractions of electric and gas intensity improvement accounted for by efficiency improvements, solar thermal, solar PV, and/or increased biomass use; fractional savings targets over (new) code levels; growth in housing stock.

Key Uncertainties

- Total commercial building space in North Carolina (regional estimates currently being used).
- Total renovated commercial space included in option per unit new commercial space (current estimate used is 0.3, based on regional and national studies).
- Fractions of new commercial buildings, and residential units, participating in program.

Additional Benefits and Costs

Benefits

Potential to also yield water savings, comfort/air quality improvements.

Costs

None cited.

Feasibility Issues

Interaction with appliance standards and utility programs.

Status of Group Approval

Completed.

Level of Group Support

Unanimous consent.

Barriers to Consensus

Not applicable.

RCI-8. Education (Consumer, Primary/Secondary, Post-Secondary/Specialist, and College and University Programs)

Mitigation Option Description

This mitigation option reflects the realization that the effectiveness of emissions reduction activities in many cases depends on providing information and education to consumers, as well as to future consumers (primary and secondary school students), regarding the energy and GHG emissions implications of consumer choices. In addition, in order to effectively implement many of the other RCI options above, specific and targeted education, outreach, and licensing requirements will be required for professionals in a variety of building-related trades in order to ensure that those professionals have the expertise to support aggressive GHG mitigation options in North Carolina.

Mitigation Option Design

Elements of this Option Design include the following:

- Training and education for builders and contractors (such as in HVAC sizing, duct sealing, building energy analysis, waste recycling, renewable energy system installation, and water distribution systems).
- Training of building code and other officials in energy code enforcement.
- Energy management training/training of building operators.
- Continuing education for building design professionals, including architects, engineers, developers, contractors, urban planners, and realtors.
- Energy efficiency and related education introduced at community colleges and trade schools.
- Consumer education programs (probable overlap with recommendations of the Cross-Cutting TWG).
- Continued funding to meet the expanding role of the SEO as a key consumer information outlet.
- Emphasize provision of resources directing consumers to information and technologies for energy-efficiency and climate impacts reduction.
- Introduce in School Curriculum (probable overlap with recommendations of Cross-Cutting TWG).

Goals: Implement training and education as described above in support of other RCI options. When implemented, more quantitative goals may be defined for the activities included in this option, such as number of persons trained in a given area. For example, goals can be quantified by identifying the number of trade professionals who go through a training program each year, the number of credits/courses offered, the number of students reached, or the fractions of applicants receiving specific types of training.

Timing: Education/Training options in place to coincide with needs to support other options recommended by the CAPAG.

Parties Involved: Code enforcement agencies, building professional trade groups, community colleges, universities, primary/secondary schools, public information agencies.

Implementation Mechanisms

The following are potential implementation mechanisms and supporting activities for this mitigation option:

- Include coverage of energy efficiency topics in the exam for general contractors.
- Include coverage of energy efficiency topics in continuing education and recertification course and exams for public school teachers.

Related Policies/Programs in Place

- Advanced Energy Corporation and NC Solar Center, and others have ongoing programs to train and educate builders and contractors and offer training in similar areas.
- Training of building code and other officials is recommended in State Energy Plan.
- SEP recommends training programs for state building operators and for private building operators.
- CSA Recommendation A-7: "Public Education on Climate Change."
- NC Air Aware provides info for teachers, focus on ozone.[30]
- **SEO Contract, Energy Management Diploma.**
- **SEO Contract, Consumer Energy Education Program.**
- **SEO Contract, Building Operator Certification.**
- **SEO Contract, National Energy Education Development.**
- **SEO Contract, Sustainable Design Competition.**
- **SEO Contract, RFP (request for proposals) for Utility Accounting Services.**
- **SEO Contract, SEO Information and Referral Center.**
- **SEP 6-1:** Development of a Solar Schools Program.
- **SEP 6-2:** The SEO can work with the state's professional licensing boards to develop a certification program for renewable energy installers.
- **SEP 8-7:** The SEO can provide training on high performance buildings to building professionals in a number of different classifications.

[30] See http://daq.state.nc.us/airaware/

- **SEP 8-8:** The SEO can provide training for building professionals on specific targeted technologies including residential daylighting, solar water heating, heat pump water heaters, new insulation products, and advanced HVAC systems and controls.
- **SEP 9-4:** The SEO can promote the use of and provide training for commercial building energy analysis.
- **SEP 10-9:** The SEO can sponsor workshops on industrial energy efficiency around the state directed at industrial facility operators, design and process engineers, and owners.
- **SEP 12-1:** Develop and sponsor training programs for community colleges and universities in fields related to energy efficiency and high performance buildings.
- **SEP 12-2:** Assist in the coordination of energy education programs with museums and help create an energy museum "on wheels" using existing resources, such as the Science House at NCSU or the Museum of Life Science, wherever possible.
- **SEP 12-3:** Sponsor regional "renewable demonstration centers" or, whenever possible, use existing ones, e.g., demonstration centers such as the North Carolina Solar House and the EnergyXchange, and museums such as the Museum of Life and Science, and Discovery Place.
- **SEP 12-4:** Create energy internships or apprenticeships for graduating college students and high school students to create the next generation of energy professionals.
- **SEP 12-5:** Provide a statewide award, e.g., a college scholarship for the most outstanding energy-related science demonstration or experiment at the state science fair.
- **SEP 12-6:** Help the Education Departments of colleges and universities develop coursework for junior and senior undergraduates and graduate students in energy education.
- **SEP 12-7:** Help Community Colleges and other vocational schools develop coursework in energy efficiency and renewable energy to help spur the industry; such as training carpentry students in energy efficient, passive solar building design and construction. Include this training in vocational-technical courses in high schools.
- **SEP 12-8:** Provide training to licensed professionals in the homebuilding industry focusing on energy efficiency and renewable energy sources to promote industry awareness and implementation of these technologies.
- **SEP 12-9:** Support development of a comprehensive information outreach program for consumer questions about saving energy and using renewables in their homes and businesses.
- **SEP 12-10:** North Carolina should encourage schools to reduce school operating budgets by installing energy efficiency and renewable energy systems.
- **SEP 12-12:** The SEO should work in partnership with the State Department of Public Instruction to plan school energy-related initiatives and include a representative for energy-use in school facilities on the Energy Policy Council.
- **SEP 12-15:** The North Carolina Community College System should require that the community colleges' curricula provide a building science course, an energy design course for drafting programs, and a solar and or renewable energy technology class.

- **SEP 12-14:** Sponsor a program to install solar equipment or other sustainable energy technologies on school buildings in every school district in the state.
- **SEP 12-16:** Establish a central repository for energy information.

Type(s) of GHG Reductions

These education and information programs are crucial in enabling and supporting GHG emissions reductions in a number of RCI areas, but their direct GHG reduction impacts are very difficult to assess.

Estimated GHG Reductions and Costs (or Cost Savings)

As this education option is primarily in support of many other options in the RCI and other sectors, quantitative savings and costs results are not evaluated here.

Key Uncertainties

Not directly applicable.

Additional Benefits and Costs

Benefits

None cited.

Costs

None cited.

Feasibility Issues

Potential contribution of consumer education programs to reducing GHG emissions is difficult to estimate.

Status of Group Approval

Completed.

Level of Group Support

Unanimous consent.

Barriers to Consensus

None.

RCI-9. Green Power Purchasing (Required for State Facilities) and Bulk Purchasing Programs for Energy Efficiency or Other Equipment

Mitigation Option Description

"Green power" supplements the state's existing power supply with electricity generated from renewable resources like the sun, wind and organic matter. This option expands an existing voluntary North Carolina program by making green power purchases mandatory for State facilities. Also included in this option is a program for the bulk purchase of appliances and equipment with higher-than-standard energy efficiency by public agencies, and for the organization of similar bulk-purchase programs in the private sector.

Green power differs from a Renewable Portfolio Standard (RPS) in that the RPS requires that electric utilities provide a certain level of renewable energy in their generation mix, while green power allows consumers to set the level of renewable energy used to provide the electricity they consume.

Mitigation Option Design

It is recommended that the use of "green power" in North Carolina be significantly expanded, and that public- and private-sector programs for the bulk purchase of high-efficiency appliances and equipment be developed.

NC GreenPower is an existing program that accepts financial contributions from North Carolina citizens and businesses to help offset the cost to produce green power. There are several options that can be implemented that would greatly increase the scope and effectiveness of the program.[31] A number of suggestions designed to mandate the use of green power in state buildings, and to encourage the development of both demand for and supply of green power in the private sector, are provided under "implementation measures," below.

Goals: State facilities purchase energy through NC GreenPower or a similar green power provider to cover 20% of their power needs by 2018, over and above the requirements of renewable generation within an Environmental Portfolio Standard or similar requirement applying to electricity suppliers. This goal would be phased in starting in 2008.

As an assessment of the adequacy of North Carolina's renewable resources to provide the required green power for this option, the December 2006 version of the La Capra report[32] lists (Table ES-2) a total renewable electricity resource potential ("practical energy potential") of

[31] NC GreenPower is an independent, nonprofit organization established to improve North Carolina's environment through voluntary contributions toward renewable energy. A landmark initiative approved by the NCUC, NC GreenPower is the first statewide green energy program in the nation supported by all the state's utilities. NC GreenPower is entirely voluntary, with the revenue going toward paying incremental costs of renewable energy generation.

[32] *Analysis of a Renewable Portfolio Standard for the State of North Carolina,* Technical Report, prepared by La Capra Associates for the NCUC, December 2006, available at: http://www.ncuc.commerce.state.nc.us/rps/NC%20RPS%20Report%2012-06.pdf

16,700 GWh (gigawatt-hours) per year by 2017, excluding capacity from offshore wind or solar PV generating resources. This potential is somewhat more than the total renewable electricity required by this and other RCI options, plus the total renewable electricity required by the sum of all Energy Supply TWG options.

Goals for bulk purchase program: Address purchase of 10% of electricity-consuming equipment purchased annually by state agencies, and 1% of electricity-consuming equipment purchased annually by all commercial/institutional sector consumers. Devices purchased under bulk purchase program consume 20% less electricity, on average, than devices that would otherwise have been purchased.

Timing: Build on the existing NC GreenPower to reach the goals above. Develop bulk purchasing programs by 2010, and ramp up to full capacity by 2018.

Parties Involved: State facilities, electric utilities, renewable energy producers, electricity consumers, and buyers of energy-using appliances and equipment.

Other: Ensure that the economic value of renewable energy generation produced in the state is included in value judgments along with air quality and other benefits.

Implementation Mechanisms

Potential implementation mechanisms and supporting activities for this mitigation option include mechanisms targeted to increasing green power demand and supply, and mechanisms that can increase the bulk purchase of high-efficiency appliances and equipment. Some of these mechanisms are described below:

The following are suggestions for state policies that are designed to increase both supply and demand for green power, thus increasing the climate change mitigation efforts. Most recommendations are also designed to improve economic development in the state.

Demand-Side Recommendations:

- In order to demonstrate leadership in this area, state facilities can be mandated to purchase a certain percentage of their power as green power (for example, through NC GreenPower or a similar agency).
- The state can provide economic development incentives for new or expanding businesses to purchase green power, and tax credits to companies that purchase green power or that support green power purchases by their employees.
- The state can provide incentives for home builders to include one year of green energy with the purchase of new homes.
- The state can provide assistance and participation in consumer and business marketing programs for green power.
- The NC DENR can work with the U.S. Environmental Protection Agency (US EPA) to ensure that green power is an option for air quality violator restitution.

- The state can ensure that the air quality benefits of renewable energy programs such as green power purchase are wedded to other benefits such as waste reduction, GHG emission reductions, and economic development.

Resource-Side Recommendations:

- The state can provide support for research efforts on, and feasibility studies of, new and developing renewable energy technologies. This support is designed to foster new technology business in the state.
- The state can provide a mechanism for long-term contract guarantees for renewable energy producers through green power programs. Currently, it is difficult to get financing for some projects due to the lack of long-term contracts.
- The state can provide support for larger renewable energy development projects. In the current program, energy is purchased after customers have signed up for the program. By sponsoring large developments prior to customer sales, the program will have more options and sales tools.
- The state can work to ease ridge laws in the mountains to allow for wind energy development. Further, the state can work with the military to provide for wind energy development in coastal areas currently being blocked.
- The state can provide low or no interest loans for qualified developers of renewable energy projects.
- Green power purchase programs will interact with supply-side RPS options, and thus their development and evaluation will need to be coordinated with Energy Supply group Mitigation Options.

For implementation of equipment and appliance bulk-purchase programs,

- Develop a list of typical bulk purchases and use this to identify which purchases to target for energy efficiency improvements.
- Bulk purchasing programs can interact with utility programs. It may be useful to use these programs in combination with standards for appliance purchases by state agencies.

Related Policies/Programs in Place

- **SEO Contract, NC GreenPower Marketing.** The North Carolina GreenPower Program has been in place for approximately 3 years. It solicits voluntary contributions from utility customers for use in subsidizing green power purchases in North Carolina (TWG member input).
- **SEO Contract, Heat Pumps in Manufactured Homes.**
- SEP recommends state procurement of environmentally preferable products.
- **SEP 7-5:** State agencies can lead by example by establishing a certain minimum level of electricity to be derived from renewable sources, such as the North Carolina GreenPower Program, or via installation of state-owned renewable energy projects.

- **SEP 7-6:** North Carolina Department of Administration can require that all state facilities with motors larger than 5 horsepower must develop a motor maintenance program.
- **SEP 10-3:** North Carolina can evaluate whether facilities that repair or rewind motors should be certified or otherwise meet a state efficiency requirement.
- General Statute 143, Article 3B: Energy Conservation in Public Facilities. Part 1. Energy Policy and Life Cycle Cost Analysis. 143-64.10. through 143-64.16.

Type(s) of GHG Reductions

GHG impacts are similar in nature to those noted for RCI-1 through RCI-3 above.

Estimated GHG Reductions and Costs (or Cost Savings)

Green Power Purchasing (required for State facilities) and Bulk Purchasing Programs for Energy Efficiency or Other Equipment	2010	2020	Units
GHG Emission Savings	0.1	0.5	$MMtCO_2e$
Net Present Value (2007–2020)		$11	$million
Cumulative Emissions Reductions (2007–2020)		3.5	$MMtCO_2e$
Cost-Effectiveness		$3	$\$/tCO_2e$

Data Sources: Commercial Buildings Energy Consumption Survey (CBECS) (U.S. Department of Energy [DOE] Energy Information Administration [EIA] commercial sector survey), incremental cost of green power from existing programs in western United States.

Quantification Methods: Apply green power requirements to State facilities, fraction of non-state buildings. For bulk purchase program, assume fraction of building energy use covered, rate of replacement of devices, and savings due to purchase of higher-efficiency devices, and apply to State and non-State electricity use.

Key Assumptions: Incremental cost for green power: $25/MWh in 2006, declining by 2017 to the average incremental cost of an estimated $16.71, associated with the 10% Renewable Portfolio Standard (for an "expanded" RPS without energy efficiency) as modeled by La Capra Associates for North Carolina.[33] Net cost of bulk purchase programs are assumed similar to net cost of market transformation programs for this initial analysis. State building electricity consumption estimate. Assumption that non-State government buildings are NOT covered by green power targets under this option.

Key Uncertainties

- Degree of coverage of State and private sector participation/purchases of electrical equipment under the in bulk purchase program, and average savings from devices purchased under the program.

[33] *Analysis of a Renewable Portfolio Standard for the State of North Carolina,* Technical Report, prepared by La Capra Associates for the NCUC, December 2006, available at: http://www.ncuc.commerce.state.nc.us/rps/NC%20RPS%20Report%2012-06.pdf

Additional Benefits and Costs

Benefits

- In some cases, green power has been more resistant to cost swings than conventional power.
- If power purchased through a green power is produced inside the state, there are also economic development benefits.

Costs

None cited.

Feasibility Issues

None cited.

Status of Group Approval

Completed.

Level of Group Support

Unanimous consent.

Barriers to Consensus

None.

RCI-10. Distributed Renewable and Clean Fossil Fuel Power Generation

Mitigation Option Description

Distributed generation with clean power systems reduces fossil fuel use and GHG emissions as well as providing electricity system benefits. Implementation of these systems should be encouraged through a combination of regulatory changes and incentive programs. This option is targeted at small to medium-sized facilities, generally less than 10 MW (megawatts).

Mitigation Option Design

It is recommended that implementation of distributed renewable and clean fossil fuel power generation systems of less than 10 MW be encouraged through a combination of regulatory changes and incentive programs. The following are elements of this Option Design:

- Review existing net-metering policies, including policies that affect electricity consumers who install on-site combined heat and power or distributed generation fueled with renewable or fossil fuels. Consider the impact of nitrogen oxides (NO_x) and power factor requirements on net-metering and availability of information for small customers.
- Review rate issues in NC, including decoupling of utility revenues from sales and rate design, with a specific focus on the impacts of rate design on GHG emissions.
- Provide incentives for renewable energy applications such as photovoltaics and other renewable power sources, including tax incentives.
- Promote clean combined heat and power in all sectors. New and existing technologies allow combined heat and power (CHP) to be used in residential, commercial sectors as well, so these sectors should be included.[34] CHP included here will emphasize smaller generation capacities.
- Fund R&D for distributed renewable and clean fossil fuel power generation.
- Provide direct or indirect support for in-state commercialization and production of new or advanced technologies for distributed renewable and clean fossil fuel power generation.
- Encourage the development of building-integrated distributed renewable and clean fossil-fuel power generation.

Goals: Implementation of 25%–33% of North Carolina's CHP potential by 2020. An additional 2%–4% of all NC homes will have solar hot water installations by 2020; and, 35 additional MW of distributed renewable generation over and above RPS-related new generation by 2020.

[34] Examples cited at the May 23 CAPAG meeting include stacks of newly developed ½ watt fuel cells, 1-kW residential CHP providing hot water, and micro-turbines for residential and small commercial applications. CHP options to be encourages may also include the use of waste heat from new electricity generation units to substitute for fossil-fueled heat in the RCI sectors. In some cases of industrial CHP, it may be necessary to assess the impact of CHP presence on given distribution circuit.

Timing: Implement changes in regulation necessary to encourage technologies by 2008. Implement incentive program by 2008.

Parties Involved: Encouraging the development of distributed renewable and clean fossil-fueled generation will require coordination and cooperation among a number of different parties, including (but not limited to) regulators (NCUC, DENR, US EPA), utilities, other state agencies, industry associations, equipment suppliers/vendors/installers, building professionals, and engineers, R&D associations.

Implementation Mechanisms

Potential implementation mechanisms and supporting activities for this mitigation option include

- Incentives to reduce first cost to a specific payback level can be coupled with requirements for new buildings. Specific implementation measures mentioned as possible for this option include tax credits, low/no interest loans, and similar financial incentives to business, industries and commercial firms to adopt CHP/distributed generation/renewables. The latter approach is especially important for small manufacturers, and could just be access to micro-loans.
- Echoing implementation mechanisms developed for options ES-3 and ES-9 by the Energy Supply TWG, support for development of CHP systems could include:
    - Encouragement CHP systems of 20 MW or smaller (or of equivalent mechanical power) by a rapid adoption and customer-friendly implementation of Federal Energy Regulatory Commission (FERC) Order 2006 for Standardization of Small Generator Interconnection Agreements and Procedures;
    - Qualify heat use from CHP systems for existing renewable and energy efficiency incentive and loan programs;
    - Allow energy service companies to sell CHP and consumer-sited distributed generation output to third party customers; and
    - Facilitate governmental and non profit organizations to easily sell renewable energy credits and tax credits to the market place.
- Support for switching to less carbon-intensive energy resources (coal and oil to natural gas or biomass, electricity to solar water heating or space/process heat).
- Voluntary emissions targets for industrial operations.
- Can include CHP/distributed generation-related/renewables R&D contracts with private firms, grants and contracts with universities, Intramural R&D conducted at government labs, R&D contracts with private/public consortia.
- Can include patent protection, R&D tax credits, production subsidies or tax credits to firms bringing new CHP/distributed generation-related/renewables technologies to market, tax credits or rebates for new technology buyers, government procurement, and demonstration projects.
- Include methane capture and use in CHP systems at sewage treatment plants as a specific focus.

- Consider integration of distributed generation options with regional demand response initiatives/recommendations.

Expanded use of distributed renewable and clean fossil-fueled power generation in North Carolina will need to be accompanied by reviews of related regulations. Such reviews could include

- Review of net-metering policies, e.g., electricity consumers who install on-site combined heat and power or distributed generation fueled with renewable or fossil fuels. This review could consider the impact of NO_x and power factor requirements on net-metering and availability of information for small customers.
- Utility Rate Reform—At the CAPAG Meeting on May 23, 2006, it was suggested that there is a need to look harder at rate issues in North Carolina, including decoupling of utility revenues from sales and rate design, with a specific focus on the impacts of rate design on GHG emissions.

Related Policies/Programs in Place

- Policy on net metering has been established by the NCUC, and corresponding tariffs approved.[35] The establishment of Small Generator Interconnection Standards[36] is designed to streamline the process for customers seeking to install net metering applications, as well as other small renewable energy generation applications.
- SEP recommends the Department of Commerce and the SEO 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, biofuels, and fuel cells.
- **SEO Contract, The Center for Energy Research and Technology.**
- **SEO Contract, Million Solar Roofs.**
- **SEO Contract, North Carolina Solar Center.**
- **SEO Contract, UNCA (University of North Caroline-Asheville) Craft Campus.**
- **SEO Contract, Sustainable Community—Carrboro Collaborative.**
- **SEO Contract, Sustainable Community—Town of Chapel Hill.**
- **SEO Contract, SEP Brownfields to Brightfields Solar Demonstration.**
- **SEO Contract North Carolina Combined Heat and Power Center.**
- **SEO Contract, NC GreenPower Marketing.**
- **SEP Exec-8:** The General Assembly should reexamine existing legislation and regulations as pertains to barriers and strategies to develop wind energy while still protecting North Carolina's natural beauty.

[35] See in Docket No. E-100, Sub 83.

[36] See in Docket No. E-100, Sub 101.

- Integration with Regional Demand Response Initiatives/recommendations is a SEP recommendation.
- **SEP 4-1:** The NCUC is encouraged to promote policies that create diversity in energy supply such as natural gas, solar energy, wind energy, biomass, and hydrogen from renewable sources with particular emphasis on in-state energy development.
- **SEP 4-5:** Because the December 2002 ice storm raised public interest in use of distributed generation i.e., in facilities used as public shelters, residential housing, etc., the SEO should study distributed generation and appropriate applications.
- **SEP 5-4:** The SEO, Department of Agriculture, and DENR should support landfill methane gas projects through direct grants and loans based on need, as well as technical assistance.
- **SEP 7-5:** State agencies should lead by example by establishing a certain minimum level of electricity to be derived from renewable sources, such as the North Carolina GreenPower Program, or via installation of state-owned renewable energy projects.
- **SEP 8-8:** The SEO should provide training for building professionals on specific targeted technologies including residential daylighting, solar water heating, heat pump water heaters, new insulation products, and advanced HVAC systems and controls.
- **SEP 10-8:** North Carolina should create policies and regulations for distributed generation in the state, including incentives for deployment of "clean" distributed generation.
- **SEP 12-14:** The SEO should sponsor a program to install solar equipment or other sustainable energy technologies on school buildings in every school district in the state.

Type(s) of GHG Reductions

- CO_2 reduction from avoided electricity production and avoided on-site fuel combustion less additional on-site CO_2 emissions from fuel used in CHP systems.
- Other gases: modest potential changes in emissions of CH_4 from avoided fuel combustion and avoided natural gas pipeline leakage, net of any additional on-site emissions or additional leakage from increased gas use, likely relatively small reductions in emissions of N_2O from avoided fuel combustion, net of any increased on-site emissions, and also some possible small net changes in emissions of black carbon, depending on the balance between avoided and additional consumption of oil, coal, and biomass fuels, and of emission control.

Estimated GHG Reductions and Costs (or Cost Savings)

Distributed Renewable and Clean Fossil Fuel Power Generation	2010	2020	Units
GHG Emission Savings	1.17	4.61	$MMtCO_2e$
Net Present Value (2007–2020)		$392	$million
Cumulative Emissions Reductions (2007–2020)		33.5	$MMtCO_2e$
Cost-Effectiveness		$12	$/tCO_2e$

Data Sources: ONSITE SYCOM CHP potential estimates; NC Solar Center (for solar PV output; California "million solar roofs" analysis for solar PV costs.

Quantification Methods: Modeled as three discrete elements:

- Solar water heating, with a target fraction of additional homes adopting solar water heaters over time and replacing a mixture of gas, electric, and liquefied petroleum gas (LPG) water heaters
- Combined heat and power, with a target fraction of North Carolina's CHP potential achieved through adoption of CHP systems fueled with gas, coal, or biomass.
- Renewable distributed generation, with a target capacity divided into residential and commercial solar PV systems and consumer-sited systems fueled with landfill gas, biomass, or biogas.

Key Assumptions: Fraction of additional North Carolina households adopting solar water heating as a result of implementation of the option. Combined heat and power generation capacity (as a fraction of North Carolina potential) achieved via RCI-10, and types of fuels used in CHP. Capacity and types of distributed renewable generation added through implementation of RCI-10.

Key Uncertainties

- Future costs of solar water heaters.
- Degree to which solar water heating targets can be attained (or exceeded).
- CHP potential in North Carolina.
- Heating fuels displaced by CHP.
- Future costs of renewable distributed generation and CHP systems.
- Types of distributed generation added.

Additional Benefits and Costs

Benefits

- Programs could help to lower capital and installation costs.
- Utility system co-benefits.
- Cost savings and decreased impacts of transmission and distribution.

Costs

None cited.

Feasibility Issues

- Cost-effectiveness dependent on price of natural gas.
- Interconnection is an issue.

Status of Group Approval

Complete.

Level of Group Support

Unanimous consent.

Barriers to Consensus

None.

RCI-11. Residential, Commercial, and Industrial Energy and Emissions Technical Assistance and Recommended Measure Implementation

Mitigation Option Description

This mitigation option includes providing residential, commercial, and industrial-sector energy technical assistance to identify options for reducing fossil energy use and reducing non-energy emissions of GHGs, along with following up on recommendations by helping to provide incentives, expertise, and information to implement recommended options.

Mitigation Option Design

It is recommended that technical assistance be provided to help identify options for energy consumers to reduce fossil energy use and to reduce non-energy emissions of GHGs, and that consumers be provided with information and incentives allowing them follow-up on that assistance to implement recommended measures. This initiative includes the following elements:

- Residential energy technical assistance for existing homes that identifies the most cost-effective energy efficiency measures, possibly including diagnostic testing of building envelopes and other home systems.
- Commercial energy technical assistance for existing commercial buildings similar to the residential services, but most likely not including diagnostic testing.
- Industrial energy technical assistance that identifies key efficiency measures, such as process heat changes, motor efficiency improvements, boiler efficiency provisions, compressed air system measures, as well as lighting and building envelope efficiency improvements. The industrial technical assistance program can identify opportunities for capture and use of process heat, as well as for implementation of combined heat and power. Opportunities for reducing the use of non-energy GHGs can also be considered.
- The technical assistance programs can include a follow-up mechanism by which those who receive services are contacted after receiving the results to answer questions and give suggestions for installing the recommended measures, and to provide access to incentives and financial assistance to encourage implementation.

Goals: Over 10,000 residential technical assistance visits, 1,500 commercial building technical assistance visits, and 300 industrial technical assistance visits can be conducted annually. Over 50% of those to whom services are provided should implement at least 50% of the recommendations. The CAPAG recommends that these goals be increased if needed to implement other RCI options.

Timing: The technical assistance program can be conducted for an initial period of 3 years beginning in 2008. Each year, an evaluation should make specific recommendations for program improvements, with a goal of increasing implementation rates. After a 3-year period, an evaluation can recommend whether to continue the program.

Parties Involved:

- Utilities: Can be involved directly in the technical assistance program, or provide funding to a separate organization.
- State Agencies: The SEO has managed several similar audit programs and can fund and/or manage the effort. The DENR could also manage the program. The State Construction Office could conduct technical assistance and analysis of state facilities.
- Third-party Efficiency Providers: North Carolina possesses considerable expertise in its universities, nonprofit organizations, and private consulting and technical service companies to conduct technical assistance services and follow-up tasks.
- Regulators: The Public Utilities Commission, with input from the Public Staff, can be involved in utility-sponsored technical assistance programs.
- Others: A wide variety of stakeholders can provide input into the development and continued operation of the technical assistance.

Implementation Mechanisms

Potential implementation mechanisms and supporting activities for this mitigation option include the following:

- Participation in Voluntary Industry-Government Partnerships. For example, Climate Leaders, a US EPA program that "encourages companies to develop long-term comprehensive climate change strategies and set GHG emissions reduction goals." A state recognition and reward program can be an effective tool for emissions reduction. This can be part of the existing Environmental Stewardship Initiative (ESI).[37] "Companies participating in Climate Leaders set a corporate-wide GHG reduction goal and inventory their emissions to measure progress."[38]
- Process Changes/Optimization. Improving manufacturing so as to require less energy and/or release less GHG process gases to the atmosphere. Impacts and costs of process changes are highly process-specific.
- Leak Reduction/Capture, Recovery and Recycling of Process Gases (gases used in industrial processes). For example, solvents used in electronics industry, recovery of refrigerants, reduction of leaks in refrigeration equipment.
- Use of Alternative Gases (other hydrofluorocarbons [HFCs], hydrocarbon coolants/refrigerants, foam blowing agents, etc.). For example, use of lower Global Warming Potential gases in specific applications, such as hydrocarbons in place of HFCs in commercial refrigeration. Some of these changes may affect energy use as well.
- Focus on Small and Medium Enterprises (SMEs). Provide resources for small and medium businesses to evaluate and pursue energy efficiency/GHG emissions reduction activities.

[37] See http://www.p2pays.org/esi

[38] See http://yosemite.epa.gov/oar/globalwarming.nsf/content/ActionsNationalPartnerships.html

- Industrial ecology/by-product synergy by including full circle of industrial by-product use within other industrial processes. For example, promote review and modification of industrial processes to encourage waste reduction, and highly efficient use of materials and energy.
- Integration with Regional Demand Response Initiatives/recommendations. This SEP recommendation might be relevant for RCI-11 in that technical assistance can be used to identify opportunities for industrial customers to participation in emergency demand reduction programs.
- Identify opportunities for water use reduction and consider the impacts of water use reduction on energy needed for, and GHG emissions due to, reduced transmission/distribution/treatment of water and wastewater.
- Focus should be on efficiency improvements that are long lived and require minimal proactive input from the customer once in place.
- Negotiated Emissions or Energy Savings Agreements. SEP recommends, for example, agreements between government and industrial or other large GHG emitters to reduce emissions on a specific time frame.

Related Policies/Programs in Place

- There are a number of efforts in North Carolina being coordinated by Industrial Extension programs. In addition, technical assistance on pollution prevention and manufacturing efficiencies is provided by the North Carolina Division of Pollution Prevention and Environmental Assistance (DPPEA), Waste Reduction Partners (WRP) and others (for examples, see below).
- **SEO Contract, DPPEA Energy Efficiency Field Assistance Waste Reduction Partners.**
- **SEO Contract, Boiler Technical Assistance Program.**
- **SEO Contract, Energy Management Program.**
- **SEO Contract, NC Industries of the Future.**
- **SEO Contract, North Carolina Combined Heat and Power Center.**
- **SEO Contract, Steam Trap Survey Program.**
- **SEO Contract, ElectriCities—Energy Auditor.**
- **SEP 9-5:** The SEO can develop an energy audit program for existing commercial buildings to assist building managers with implementing the most energy efficient and cost effective improvements for commercial renovation projects.
- Industrial Assessment Center at NCSU provides energy conservation and cost reduction assessments to small to medium sized enterprises.[39] This type of assistance is also currently provided by DPPEA and WRP, as well as the IES. In addition, the types of activities suggested in options 9.6 and 9.7 are also provided by DPPEA and WRP, and can be included in the demand-side management recommendation as part of RCI-1.

[39] See http://www.mae.ncsu.edu/Centers/IAC/

- Industrial Extension Services at NC State University provides surveys and audits of industrial operations to provide suggestions on cost savings from energy efficiency.[40] Waste Trader, an on-line waste exchange system, and Biomass Trader, a similar system for biomass, are joint projects between DPPEA and SEO that are relevant to this option.[41]
- WRP in Western North Carolina carries out technical assistance visits in the commercial/institutional and industrial sectors. The WRP program is staffed largely by volunteer retired engineers, and provides limited "energy audit" services (Terry Albrecht of WRP, personal communication).
- Greenville (NC) Utilities operates a longstanding (since 1977) residential survey/audit program, which frequently identifies savings potential for residential customers of up to 50% in overall energy use. Savings found commonly include building envelope and heating/cooling system measures, but also hot water system measures including simple plumbing fixes (personal correspondence with Andy Yakim of Greenville Utilities, May 25, 2007).
- The U.S. Environmental Protection Agency offers energy efficiency audits in many states, and several audits have been performed (by local contractors) under the EPA program on buildings in North Carolina, including at NCSU.

Type(s) of GHG Reductions

GHG impacts are likely similar in nature to those noted for RCI-1 through RCI-3 above, except that to the extent that voluntary emissions reduction efforts included as a part of this option target non-energy emissions, GHG impacts will vary on a case-by-case basis.

Estimated GHG Reductions and Costs (or Cost Savings)

Residential, Commercial, and Industrial Energy and Emissions Technical Assistance and Recommended Measure Implementation	2010	2020	Units
GHG Emission Savings	0.5	2.1	$MMtCO_2e$
Net Present Value (2007–2020)		–$494	$million
Cumulative Emissions Reductions (2007–2020)		14.9	$MMtCO_2e$
Cost-Effectiveness		–$33	$/tCO_2e$

Data Sources: Adjusted costs of saved energy by sector were adapted from data in the GDS Report for the NCUC.[42]

Quantification Methods: Start with target number of technical assistance visits per sector per year, and apply estimates of fractional savings per visit (via recommended measures adopted) as a fraction of per-consumer electricity, natural gas, LPG, and oil demand. Estimate net costs of

[40] See http://www.ies.ncsu.edu/energysurveys/

[41] See http://www.p2pays.org/

[42] GDS Associates, Inc. Report for the NCUC, *A Study of the Feasibility of Energy Efficiency as an Eligible Resource as Part of a Renewable Portfolio Standard for the State of North Carolina,* December 2006.

energy savings for electricity and non-electric fuels, by sector, and calculate cost difference relative to electricity and gas avoided costs, and to other fuel costs.

Key Assumptions: Actual savings achieved per customer; number of technical assistance visits per sector per year.

Key Uncertainties

- Savings achieved per customer.
- Growth rate of customer count by sector.
- Cost of energy savings, including costs of technical assistance visits themselves (and including costs of visits that result in no consumer adoption of measures).

Additional Benefits and Costs

Benefits

None cited.

Costs

None cited.

Feasibility Issues

Impact, cost of process changes/optimization likely highly process-specific.

Status of Group Approval

Completed.

Level of Group Support

Unanimous consent.

Barriers to Consensus

None.

ANNEX A TO RCI Mitigation Option Recommendations

Summaries of North Carolina State Energy Office (SEO) and State Energy Plan (SEP) Policies and Programs Related to RCI Mitigation Options

Note: The Summaries that follow were provided by Len Hoey of the NC State Energy Office, and are referred to when applicable in the "Related Policies/Programs in Place" sections of the Options Descriptions above.

State Energy Office Contracts and Programs

- **SEO CONTRACT, Appalachian State University Energy Center:** The North Carolina General Assembly established the Energy Policy Council in 1975 as a means of addressing state-specific energy issues and concerns. The State Energy Plan is the Council's biannual, comprehensive examination of energy use, energy production and environmental concerns in the state. As in years past, the Appalachian State University Energy Center (ASUEC) has been contracted by the State Energy Office to prepare the State Energy Plan based on the recommendations of the Energy Policy Council, updating and revising the Plan for 2007. The Center is also responsible for assisting the State Energy Office in implementing the recommendations of the State Energy Plan. As part of its implementation duties, Appalachian State University performs the following tasks, among others:
  - Provides data on the potential for energy efficiency in various customer segments, preparing a final analysis and report for submission to the State Energy Office and Energy Policy Council.
  - Coordinates the North Carolina Fuel Cell Alliance to further expand the fuel cell industry in the state.
  - Updates economic analysis of standard and renewable electricity technologies due to changes in fuel costs, including projections of renewable electricity potential.
  - Works with the North Carolina Economic Development Board in creating a strategy that informs the state's businesses and government leaders on the potential of renewable energy industries as part of the state's technology-based economic development strategy.
  - Works with officials at several North Carolina landfills to conduct technical and economic analysis of landfill energy production for fuel and electricity generation.
  - Provides input into statewide transportation policy and planning by developing a design for modular biodiesel plants; working with area farmers on production of crops for conversion to biofuels; working with other state transportation efficiency efforts to reduce dependence on petroleum-based transportation; and providing

technical support to statewide agencies and universities to displace 20% petroleum use in state vehicles.

  - Provides commercial building efficiency outreach by working with State Construction Office officials to develop new energy standards for State buildings and an evaluation and monitoring system to assure the use of these standards.
  - Promotes high performance homes by conducting sessions for production builders on new ENERGY STAR® homes; conducting a North Carolina-based ENERGY STAR conference; developing new home designs based on input from affordable housing groups; and conducting workshops on the Zero Energy Home concept and design.
  - Furthers energy education by holding meetings with school officials about building energy use, energy-related curricula and energy demonstration projects.
  - Furthers renewable energy initiatives in the western part of the state by purchasing and loaning an anemometer tower to assess wind development sites; providing consultation services for wind assessments; conducting workshops on residential- or farm-scale wind energy; and developing ordinances and working with local officials regarding wind turbine permitting.

- **SEO CONTRACT, Energy Management Program:** This program, operated in conjunction with the North Carolina State University (NCSU) Industrial Extension Service, provides workshops and industrial energy surveys that identify opportunities and demonstrate techniques for optimizing energy use in various building systems and promoting energy conservation in industrial, institutional, commercial and governmental buildings. Industrial surveys provide comprehensive audits of common system inefficiencies (such as leaky compressed air systems, poorly-adjusted steam traps, etc.) and provide recommendations for energy improvements. The tasks involved in this project include performance of energy surveys, development of energy-saving recommendations, technical assistance, development, implementation and promotion of workshops and educational materials.
- **SEO CONTRACT, The Center for Energy Research and Technology:** The Center for Energy Research and Technology, housed at North Carolina A&T (Agricultural and Technical) State University, provides education, training, demonstration and technical assistance on energy and environmental technologies. Programs fall under three main areas: technical transfer (outreach), demonstration and the manufactured housing research initiative. Recent projects have included the installation and monitoring of a photovoltaic system installed on residential buildings; collection and analysis of survey data on customer complaints of manufactured homes; a demonstration energy efficient manufactured home; industrial workshops on heating, ventilation, and air conditioning (HVAC) operation and indoor air quality; summer “energy camp” programs to introduce secondary school children to various energy systems and encourage their entrance into the energy field; and assessment of wood residues in the state available for energy production.
- **SEO CONTRACT, Energy Efficiency for Nonprofits:** The Nonprofit Energy Efficiency Program works with small- to medium-size private and public nonprofit agencies, including local governments and schools, to install low-cost energy efficiency

measures that will reduce operating expenses. Where possible, volunteers from the nonprofit organization are trained to install the measures under supervision of trained contractors, utility personnel and staff from the State Energy Office and collaborating groups. Emphasis will be placed on measures that have a ten-year or better payback. Energy bills for a selected sample of organizations will be monitored for at least one year following installation to determine actual energy costs savings. A match of $100,000 was provided by Piedmont Natural Gas for this program.

- **SEO CONTRACT, ElectriCities—Energy Auditor:** Energy audits, once a common utility service for residential customers, are now rare offerings. The state's three major utilities do not offer them, and only a handful of municipal and electric cooperatives offer them. The savings potential from a home energy audit is enormous, however, particularly in light of the rapidly increasing costs of today's utility bills. ElectriCities of North Carolina, Inc., with support from the State Energy Office, will maintain a two-year program for a circuit riding energy auditor to provide energy audit services to residential customers of municipal electric distribution systems in northeastern North Carolina. The goal of the project is to conduct 1,000 on-site energy audits and to offer 100 energy education workshops with estimated attendance of 1,000 people over the project's two-year span. In addition, the project will make a Web-based energy audit service available to all ElectriCities residential customers, enabling many more additional audits to be conducted. Savings to consumers will vary, though an average of 15% for residential energy costs, or nearly $300 per household, is a safe assumption. Environmental benefits, based on reduced energy use, will be significant.
- **SEO CONTRACT, Energy Efficiency Field Assistance Waste Reduction Partners:** Waste Reduction Partners is a team of 51 volunteer and retired engineers, scientists and architects that provides waste reduction and energy efficiency assistance to businesses, industries and public facilities in the state's 37 western-most counties. With support from the State Energy Office, Waste Reduction Partners is serving a critical community need by responding to requests for on-site energy-efficiency technical assistance, strategic energy management planning, and implementation facilitation for western North Carolina industries, businesses and public facilities, including primary and secondary public schools, local governments and state agencies. This assistance is free and supports the objectives of the State Energy Plan and the State Energy Office's Utility Savings Initiative.
- **SEO CONTRACT, Central and Eastern Waste Reduction Partners:** This initiative will create a Waste Reduction Partners technical outreach program to assist central and eastern North Carolina businesses and institutions in becoming more energy efficient, economically competitive and environmentally sustainable. This project expands on the successful western North Carolina Waste Reduction Partners program of the Land-of-Sky Regional Council of Governments (COG) in Asheville, which utilizes the technical expertise of 51 retired volunteer engineers and scientists working in conjunction with program staff.
- **SEO CONTRACT PEM Fuel Cell:** In order to showcase the beneficial uses of polymer electrolytic membrane (PEM) fuel cells, the North Carolina Solar Center at NCSU is building a fuel cell demonstration model that will provide supplemental power to the

Center's new alternative fuel vehicle garage. Specifically, the operational system will consist of a commercial electrolysis unit powered by photovoltaic panels on the roof of the garage, a low pressure hydrogen storage tank, a commercial PEM fuel cell, and an inverter to convert the fuel cell output to 120 volts alternating current (VAC). A benchtop demonstration model featuring see-through, micro-power versions of the main operational system components will further educate the public about the benefits of PEM fuel cells and hydrogen power. The demonstration model will benefit from existing outreach activities of the Center's NCSU Solar House, which has welcomed over 250,000 visitors since it opened in 1981.

- **SEO CONTRACT Landfill Gas Conference:** The objective of the Landfill Gas and Combined Heat and Power: Technologies and Opportunities Conference was to further develop distributed energy projects that utilize landfill gas fuel around the southeastern United States. The North Carolina Solar Center acted as the lead agency, with State Energy Office support, in organizing three of these short conferences to examine landfill gas energy production technologies and to share success stories within the region. The conferences also spotlighted common and potential hurdles to implementing a landfill gas system in a community and how to overcome these hurdles.
- **SEO CONTRACT Energy Management Diploma:** The Energy Management Diploma Program is a fourteen-day course over approximately six months that trains state, local government, nonprofit, university and community college officials in the development and implementation of effective energy management programs. Upon the successful completion of the course and a written exam, students receive a Diploma in Energy Management from NCSU.
- **SEO CONTRACT Consumer Energy Education Program:** The Consumer Energy Education Program, also known as E-Conservation, was created to inform and educate North Carolina consumers about ways to both reduce energy use and increase energy efficiency in the home. Most North Carolina utility companies have eliminated or significantly reduced their consumer energy awareness and education programs. This project is designed to help consumers reduce home energy consumption and assist them in saving money through no-and low-cost energy efficiency measures, behavioral changes and home retrofits. Trained county extension agents offer consumer education workshops, conduct home energy audits, distribute consumer energy kits with information on energy conservation and efficiency, participate in community events, and develop partnerships with other energy professionals. The agents provide ongoing evaluations to determine the effectiveness of the E-Conservation energy education program.
- **SEO CONTRACT Building Operator Certification:** This project will promote energy conservation in state and local government, institutional, commercial and industrial buildings throughout the state. This will be accomplished by introducing the Building Operator Certification Program to North Carolina through community-college based training courses. The program will provide training in energy-saving building operating practices and in identification and implementation of energy-conservation projects for building operators (e.g., school facilities staff).

- **SEO CONTRACT National Energy Education Development:** The National Energy Education Development Program is dedicated to implementing comprehensive energy education programs in the nation's schools. This will be accomplished by creating effective networks of education, business, government and community leaders to design and deliver objective, multilateral energy education programs. In North Carolina, the project will train 200 teachers and reach 9,000 students directly.
- **SEO CONTRACT, Sustainable Design Competition:** The NC Sustainable Building Design Program aims to integrate the foundations and principles of sustainable design into college-level curriculums. The main event in this program is the annual Sustainable Building Design Competition. Through this competition, students create a residential structure that is later built and used as a model "sustainable" house. Student teams are from diverse curriculums and are encouraged to create multi-institutional and cross-curriculum teams. Students enter the workforce experienced in and knowledgeable about energy efficient, sustainable design. The program, now in its sixth year, has involved over 1,200 students, professors and professionals and 10 North Carolina community colleges and universities. Support from the State Energy Office will help ensure the expansion of the current program to include more mainstream sustainable design options through demonstration projects and more participating schools. It is the vision of the competition organizers to recruit five additional schools per year totaling 20 schools by the 2008 academic year. This would impact approximately 2,000 students, professors and professionals by 2008.
- **SEO CONTRACT, RFP for Utility Accounting Services:** The purpose of this program is to provide utility data input and collection for state agencies, the University of North Carolina system, community colleges, primary and secondary public schools and local governments. This is not a contract as each individual participant will create their own purchase order referencing this request for proposals (RFP).
- **SEO CONTRACT, State Energy Office Information and Referral Center:** The State Energy Office information and referral center manager will create and manage an on-site and virtual information center. Duties will include acquiring, organizing and disseminating information through the State Energy Office Web site, exhibitions, workshops, conferences, media events, mailings, on-site visits, telephone calls and other activities. This position will be the initial contact for public inquiries and two-way communication about energy information. This position will be responsible for both online and print material selection, printing contracts and publication development and distribution. Additionally, this position will be responsible for developing promotional strategies for State Energy Office information services and collecting and organizing Information and Referral Center statistics.
- **SEO CONTRACT, Heat Pumps in Manufactured Homes:** Historically, nearly one-third of the new homes sited annually in North Carolina are manufactured homes (formerly referred to as mobile homes). Many consumers choose manufactured homes because they offer a more affordable housing option for their families. The benefits of a lower monthly mortgage payment are often negated by the additional monthly operating expenses of an electric-resistance furnace, however. In some instances, the monthly winter utility payment may actually be higher than the monthly mortgage payment. The

approximate cost of upgrading a manufactured home from the standard forced-air, electric-resistance furnace with central air conditioning to an energy-efficient heat pump (to provide both heating and cooling) is about $400 per home. Homeowners who upgrade to an energy-efficient heat pump can expect to save $375 to $750 per winter heating season in energy costs. With the support of the State Energy Office, the Eastern Carolina University College of Technology and Computer Science developed an "upgrade and save" program that has secured the participation of 37 manufactured home retailers in 17 eastern North Carolina counties. The program reimburses both retailers and existing manufactured homeowners for the approximate cost to upgrade to an energy-efficient heat pump. Around 130 homes have received upgrades to date. The next phase of the program is detailed below.

- **SEO CONTRACT, NC GreenPower Marketing:** North Carolina GreenPower is a statewide program designed to improve the quality of the environment through development of renewable energy resources using consumers' voluntary purchase of green power through electric utilities in North Carolina. The program revenues provide financial incentives for generators of electricity from renewable sources. The four main objectives of the program are to improve the quality of the environment; increase the amount of generation from renewable and alternative energy sources; maximize the amount of investment in renewable generation; and maximize the number of participants in the program. The objective of the marketing and outreach project is to expand the statewide advertising, communications and education campaign to promote the use and development of renewable energy generated in North Carolina. Particular emphasis is placed on increasing corporate sales activities, through which the program most effectively and more readily can reach its participation goals.
- **SEO CONTRACT, Million Solar Roofs:** The Million Solar Roofs Partnership, administered by the North Carolina Solar Center at NCSU, helps supports local organizations in eight locations around the state in continuing educational outreach and advocacy projects supporting solar technology deployment. Examples of local projects include educational forums, solar home tours, technology demonstrations, technology workshops, local policy support, tracking local solar installations, and support for North Carolina GreenPower, an independent, nonprofit organization established to improve North Carolina's environment through voluntary contributions toward renewable energy. The partnerships are in Asheville, Charlotte, Fayetteville, Wilmington, Chapel Hill, and the counties of Guilford, Durham, and Watauga.
- **SEO CONTRACT, North Carolina Solar Center:** Created in 1988, the North Carolina Solar Center serves as a clearinghouse for renewable energy programs, information, research, technical assistance, and training for professionals and consumers in North Carolina. The Solar Center is operated by the College of Engineering at NCSU. The activities and initiatives funded by this program will move North Carolina closer to a sustainable energy future through technology transfer programs, extensive workforce development programs, and efforts to educate the public and shape government policy. The Center has served as the lead agent of the State Energy Office for nearly two decades in the area of active and passive solar energy, and has in recent years assumed a leadership role in a broader array of renewable power and industrial efficiency

technologies, high performance building systems and alternative transportation fuels and technologies.

- **SEO CONTRACT, UNCA Craft Campus:** The University of North Carolina at Asheville is building a new Craft Campus close to their main campus and downtown Asheville. In addition to providing a central location to display the work of western North Carolina and University of North Carolina-Asheville (UNCA) artists, the Craft Campus will serve as a demonstration site to showcase and teach the public about a variety of renewable energy technologies. The campus design team has developed a cohesive, systematic view focusing on green building principles that integrate studio needs, public spaces and on-site energy sources including landfill gas, wind, water, and solar power. This will be the only site in North Carolina comprehensively demonstrating the renewable energy and energy efficiency technologies that could impact our lives in the near future.
- **SEO CONTRACT, Sustainable Community—Carrboro Collaborative:** This demonstration project is intended to provide solar-assisted hot water and photovoltaic lighting for the "common house" in the Pacifica neighborhood located in Carrboro, NC. This highly visible project will be located in a sustainable Orange County subdivision that consists of 46 energy efficient low- to moderate-income homes. The homes in the Pacifica neighborhood will provide this project with a complimentary demonstration of high performance homes. Forty-two of the 46 homes have a passive solar design, 16 have solar hot water systems, 11 have whole house instantaneous hot water systems and 19 have hot water-heated radiant floors. It is projected that local, regional and statewide builders, developers and potential new home purchasers will tour the site to learn about the advantages of solar water heating and photovoltaic lighting. Recent emphasis on alternative, sustainable energy sources coupled with the current increase in fuel costs will help to raise consumer awareness of this sustainable option.
- **SEO CONTRACT, Sustainable Community—Town of Chapel Hill:** The purpose of this project is to provide funding for the purchase and installation of a photovoltaic system at the Town of Chapel Hill's Fire Station Number 1.This upgrade will be an extension of an earlier sustainable community grant, which the town utilized to successfully complete an energy audit and several efficiency upgrades, including installing energy efficient doors and windows, upgrading the efficiency of the HVAC units, replacing inefficient appliances with ENERGY STAR-rated appliances and purchasing two solar exterior lights.
- **SEO CONTRACT, SEP Brownfields to Brightfields Solar Demonstration:** "Brightfield" is a term that was coined by the U.S. Department of Energy (US DOE) to describe redevelopment projects that incorporate renewable energy or distributed energy generation systems into the redevelopment of "Brownfields," or industrial and commercial facilities where expansion or redevelopment is complicated by real or perceived environmental contamination. Such was the case of Lot 86 on the NCSU campus in Raleigh where, during the 1970s and 1980s, the site was used as an agricultural pesticide dump. Carolina Green Energy, formed in 2004 to build renewable energy generation in North Carolina, will build, own, and operate a 35-kW photovoltaic power generation project on Lot 86. The electricity generated will be sold to Progress Energy under an avoided cost contract and the renewable energy certificates will be sold

to North Carolina GreenPower under a separate contract. North Carolina GreenPower is the first statewide green energy program in the nation supported by all the state's utilities and administered by a nonprofit corporation. The goal of North Carolina GreenPower is to supplement the state's existing power supply with more green energy, or electricity generated from renewable resources such as the sun, wind and organic matter. All proceeds from this project's electricity sales and green power certificates will be used to cover operational costs, maintenance costs and equipment financing charges.

- **SEO CONTRACT North Carolina Combined Heat and Power Center:** Combined heat and power technologies offer many benefits to society. Conventional means of generating electricity typically convert 33% or less of the energy available in a fuel source into useful energy for consumers; the other 66% of the energy potential is discarded as waste heat. A regional combined heat and power center can help situate power generation technologies near locations that require a heat source. The "waste heat" from generating electricity can be used to satisfy heating requirements. Various technologies can even allow the "waste heat" to be converted so that cooling and dehumidification needs can be met. This project will continue support for the North Carolina Combined Heat and Power Application Center to promote combined heat and power applications throughout the state. This will be accomplished by continuing assessments of potential sites at public and private facilities that could host combined heat and power, assisting in the development of demonstration sites, supporting a broader market acceptance of combined heat and power concepts and technologies, and providing regular monthly status reports tracking progress of the program.
- **SEO CONTRACT, DPPEA (Division of Pollution Prevention and Environmental Assistance) Energy Efficiency Field Assistance Waste Reduction Partners:** Waste Reduction Partners is a team of 51 volunteer and retired engineers, scientists and architects that provides waste reduction and energy efficiency assistance to businesses, industries and public facilities in the state's 37 western-most counties. With support from the State Energy Office, Waste Reduction Partners is serving a critical community need by responding to requests for on-site energy-efficiency technical assistance, strategic energy management planning, and implementation facilitation for western North Carolina industries, businesses and public facilities, including primary and secondary public schools, local governments and state agencies. This assistance is free and supports the objectives of the State Energy Plan and the State Energy Office's Utility Savings Initiative.
- **SEO CONTRACT, Boiler Technical Assistance Program:** The Boiler Technical Assistance Program helps state-operated and industrial, commercial and institutional facilities measure and improve boiler efficiency and implement boiler-related energy conservation measures. This is accomplished through statewide workshop presentations and on-site boiler surveys. The workshops teach participants how to confront their boiler problems, work through solutions and return to their jobs with the tools to solve their own in-plant problems. The on-site boiler surveys offer boiler system evaluations and technical assistance to those institutions that attend one of the workshops. Potential beneficiaries include industry engineers, systems operators and boiler operating personnel from schools, hospitals, state government agencies and universities.

- **SEO CONTRACT, NC Industries of the Future:** The North Carolina Industries of the Future program will assist North Carolina industry in implementing innovative energy efficiency methods to become more globally competitive. Industrial sector businesses that are large energy users will be targeted for this program, with a focus on the five originally-designated North Carolina Industry of the Future sectors of glass, agriculture, forest products, chemicals and mining. Best practices training workshops will be provided for each of the industry sectors, and assessments for 12 energy-intensive facilities will be distributed among the sectors and other large energy users. Reports on program progress will be presented for the stakeholders to self-assess the progress and effectiveness of the program and to redirect efforts if necessary in order to achieve success.
- **SEO CONTRACT, Steam Trap Survey Program:** The purpose of this program is to provide steam trap survey services to a variety of North Carolina industrial facilities, commercial businesses, local government and institutional facilities using steam for heating and/or processing. Steam traps are identified, tested and tagged if not working properly. These services enable facilities to cut steam loss, thereby saving energy and money. Program participants receive a fixed amount of funding for each steam trap surveyed. The surveys are conducted by approved firms.

State Energy Plan Policies and Programs

- **SEP Exec-1:** The North Carolina Department of Commerce and the State Energy Office 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, renewable energy equipment, biofuels, and fuel cells. The ASUEC has developed info on energy-related jobs and economic impact and has met with industry and economic development leaders to discuss how to bring more energy-related business and jobs to NC. Summary information has been presented to economic developers in four of the seven NC economic development regions to date in 2004. A handbook on renewable energy data available in the database is under development. The NC Solar Center staff provided financial incentives consultation to Carolina Green Energy to support potential development of a coastal NC wind farm. The NC Solar Center (NCSC) and SEO partnership provides services that support companies that produce and/or install renewable energy technologies. A directory of professionals offering services in various categories of renewable technology is available to the public. And, the NCSC offers design reviews, for both residential and commercial developments, that detail energy savings opportunities and encourage use of renewable design features. The NCSC supports the development of renewable energy through training for contractors, trades people, designers, and others on a range of topics that include solar electricity, solar heating, sustainable design, and day lighting.
- The Million Solar Roofs program, coordinated through the NCSC, has established 7 partnerships around the state. Partnerships have developed strategic plans that highlight steps to encourage the use of solar technology. A small grants program supports solar technology demonstration projects in local partnerships areas. Hosted by SEO and the

North Carolina Department of Natural Resources (DENR), an interagency landfill gas steering committee has been meeting to discuss issues and opportunities related to converting landfill gas to energy. The group also has participation from Commerce, NCSC, NC GreenPower, The U.S. Environmental Protection Agency's (EPA's) Landfill Methane Outreach Program (LMOP), landfill gas developers, and the Carolinas Solid Waste Association. Major issues revolve around regulatory, administrative, and industry proximity. The group sponsored an NC landfill gas conference on December 10, 2004, at the McKimmon Center. As part of this conference, a generation information system (GIS) mapping effort by NC OneMap showcased the proximity of 131 LMOP landfills to potential landfill gas (LFG) users. An LFG focus group has met to discuss and identify the barriers to LFG development. These barriers are expected to be discussed with the Public Utilities Commission (PUC) staff to attempt to resolve the issues. LFG development studies are to be conducted for sites owned by Buncombe County, Robeson County, City of Durham, and 20 other sites identified as top prospects for development. The Schools Going Solar project, coordinated through The National Energy Education Development (NEED) Project, allows schools to receive photovoltaic installations and solar energy curriculum and training programs in order to facilitate both an understanding of the impact of solar energy and its diverse applications. The NC Schools Going Solar Project will install a total of six systems with the majority of them being placed in Million Solar Roof communities. The NEED Project anticipates installation at all six schools by the end of October 2005. Continue to investigate cost-effective solutions for National Guard 25 kW power backup application. Prepare and present PowerPoint presentation on hydrogen fuel cells for power backup applications during Utility Savings Initiative (USI) Steering Committee meeting on August, 24. Meet with Hydrogen Economy Advancement Team, to review the Raleigh-Durham (RDU) Airport presentation briefing on August 12 (DENR). Meet with "Fuel Cell Roadmap Team" on August 16, Chapel Hill. NC A&T State University purchased and installed a PEM fuel cell on campus as a demonstration in April 2005. The performance of the fuel cell application will be studied and recommendations made in terms of widespread use of fuel cells. The NC GreenPower program now has over 7,000 participants who are supporting the purchase of almost 17,000 blocks of 100 kWh. This amounts to approximately 20 million kWh annually of green power purchases. The program has 11 small PV providers, a 35 kW project planned, 2 landfill operations and a swine waste generator as part of the mass market program. The large volume product has a small hydro aggregation generator, a portion of the Craven Wood Waste output, and a swine waste plant as part of the program. SEO supports the marketing and outreach portion of NC GreenPower as do the utilities and Advanced Energy.

- **SEP 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. The RPS would require that all electric utilities increase the percentage of total distributed electricity that comes from renewable sources, such as hydroelectric, wind, solar, waste-derived fuels, and agricultural fuels.
- **SEP Exec-8:** The General Assembly should reexamine existing legislation and regulations as pertains to barriers and strategies to develop wind energy while still protecting North Carolina's natural beauty. With SEO and US DOE support, a statewide

map showing wind development potential has been developed. A mountain wind attitudes study has been completed, showing strong support for wind among local residents. Scenic view protection must be incorporated into wind turbine location. An environmental analysis is being conducted to determine endangered species of plants and animals that could be impacted by wind power development. ASU completed a coastal wind attitudes survey and prepared a report to the Coastal Wind Working Group. Coastal residents also showed support for area wind development although respondents did note concern for placement of wind turbines in national forests and in sounds. A Small Wind Demonstration Center has been established at Beech Mountain, NC. The center currently has 6 wind turbines installed and these are generating electricity for sale to Mountain Electric Coop. A Web site for information about the project is at http://www.wind.appstate.edu/swiwind/swi.php. NC Coastal Wind Assessment and Coastal Wind Working Group continue to address regulatory, financial, and environment issues. In addition, a coastal anemometer program has sited 6 anemometers to collect wind data. Additional information is at http://www.ncsc.ncsu.edu/programs/The_Coastal_Wind_Initiative.cfm.

- **SEP Exec-9:** The State Energy Office 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 daylighting. SEO is co-sponsoring, funding, and actively participating in the NC GreenPower Program. The program is currently averaging 20M kWh annually in contributions and should result in significant expansion of renewable electricity generation in NC. Clean Technology Demonstration RFP contracts have been awarded to the following: ASU (NC Small Wind Initiative), the NEED Project (solar panels in schools), Wake Technical Community College (E85[1] Infrastructure), and Central Carolina Community College (Biofuels from Cooking Waste). ASUEC has conducted research on potential savings associated with widespread adoption of residential solar water heating systems tied to new construction. This included telephone interviews with solar dealers in NC and national manufacturers. Discussions are underway with several residential developers interested in installing solar water heating systems in new homes. An NC Daylighting Consortium has been established through the NCSC. This consortium has the following goals: identifying and evaluating daylighting resources; adopting standard evaluation protocol; and facilitating the inclusion of daylighting technologies in professional practice to improve building performance in an environmentally sustainable manner. NC HealthyBuilt Homes (HBH), a green builder program, has been developed and promoted to builders. This program offers builders marketing incentives and access to information that supports renewable technologies. Visit the following Web site for current information: http://www.ncsc.ncsu.edu/programs/ North_Carolina_HealthyBuilt_Homes_Program.cfm. The HBH program now has 27 builders statewide and 55 homes that are underway. 7 homes have been completed under the program. The HBH is targeted to small and medium sized builders. The first project that used NC HBH exclusively has been completed by Mountain Housing Opportunities, Inc. in Asheville. The 15 units in this low-income, green housing development were all certified as HBH. Sustainable building concepts and products, such as passive solar design, solar water

[1] E85 is a term for motor fuel blends of 85% ethanol and 15% gasoline.

heating and environmentally-friendly products, were featured in this "Green Building Demonstration" project. Under the Sustainable Community Development RFP, the SEO has issued contracts to Carrboro Collective, Blue Ridge Resource Conservation & Development Council, Altamont Environmental, and Town of Chapel Hill for projects with renewable energy elements. The "Guide to Interconnection of Small PV [Photovoltaic] Systems for NC GreenPower" was published. This guide describes steps necessary for interconnection and notes required forms and documents.

- **SEP Exec-10:** The General Assembly should require that all electric utilities in North Carolina 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 Web site. The disclosure information should clarify to the consumer the environmental impact of residential electricity use. The NC GreenPower Program must clarify the extent to which disclosure of fuel mix and emissions is required to maintain the Center for Resource Solutions' national certification as a valid green product. The ASUEC has prepared a disclosure briefing paper with recommendations for legislation requiring suppliers of electricity to report semi-annually, via bill insert, on respective mix of fuels and emissions.

- **SEP Exec-11:** State agencies and universities, with coordination by the North Carolina Department of Administration, should reduce energy consumption in existing state buildings to save 20% by 2008, 4% per year or more for the next 5 years. The State Energy Office should submit an annual report to the Energy Policy Council, the Governor's Office, the State University System and other major energy users in North Carolina that provides data on energy saved in state buildings and universities by source and cost, energy efficiency activities undertaken in these buildings, the approximate investment in energy efficiency measures, and the overall economic costs and benefits of the program. The program is centered on a goal of reducing energy consumption in state agencies by 20% over a five-year period ending in 2008. Since the program's inception, the Utility Savings Initiative while spending $2,347,599 (since 2003) has saved the State of North Carolina more than 2,135,260 MMBtu (million British thermal units), with $33 million in avoided costs. The program recently has been expanded to the state's community colleges and will be provided to local governments and public school systems in the near future. The program uses a four-pronged approach to achieve its goal; utility accounting, operations and maintenance, awareness and training and performance contracting. For tracking purposes, energy consumption is indexed by gross square feet to accommodate growth in state facilities.

- **SEP Exec-13:** North Carolina should facilitate efforts of local governments to finance energy efficiency and renewable energy projects; specifically, allow bundling of multi-jurisdictional energy efficiency projects to achieve economies of scale and improve opportunities for financing, restructure the underwriting provisions of the State Energy Office's low-interest energy loan program, and provide training in energy efficiency measures to building managers in local government buildings. SEO and Department of Public Instruction (DPI) co-sponsored training for the state's 117 school districts that will result in preparation of local strategic energy plans for K-12 schools. The DPI sent 51 persons, representing 40 school systems, to three regional SEP workshops in May 2004. An additional workshop was held in December 2004 for 45 attendees, representing 30

school systems. SEO sponsored four energy efficiency and sustainability workshops for administrators and facility directors of K-12 schools. The workshops for school officials were organized by NEED and US DOE's Energy Smart Schools Program. The SEO assisted in planning for the SEQL (Sustainable Environment for Quality of Life) program for local governments in the Charlotte Metro region. Local governments (county, municipal, K-12) were invited and attended SEO performance contracting training. Local governments are encouraged to use the SEO list of qualified energy service companies, RFP template, and other sample documents for performance contracting. Site visits and technical analysis by SEO staff are available to local governments also.

Training in energy efficiency measures under USI is available to local governments. The 2004 Energy Management Diploma class includes several community college, K-12, county and city government energy managers. A contract with Waste Reduction Partners provides local government energy audits in western NC, investigates financing options for energy projects, and offers follow-up technical assistance for strategic planning and implementation. Permanent rules have been approved by the Rules Review Commission for both performance contracting in State-Owned Buildings and for the Energy Improvement Loan Program. The approved Rules will be available on the SEO Web site in September for performance contracting and in October for the loan program. A standard RFP and an Investment Grade Audit (IGA) template have been reviewed by the Attorney General's (Ag's) Office. A standard Energy Services Agreement is presently being reviewed by Attorney General's (AG's) Office. Performance Contracting Training for Public Housing Authority staff is scheduled for October 28–29, 2005, in Raleigh. Performance Contracting Training for Community Colleges was held November 10, 2004, in Enka, NC. Requests for Proposals for Performance Contracting have been evaluated for the Museum of Art, University of North Carolina-Greensboro (UNCG), and the downtown chiller loop which will include more than 10 buildings in the downtown government complex. The Department of Correction has issued an RFP for performance contracting at Nash, Harnett, and Women's prisons. SEO has provided performance contracting assistance to Scotland, Yancey, and Alleghany Counties and to Durham Tech. The North Carolina Department of Administration (DOA) Legal Counsel has approved all documents related to the Energy Improvement Loan Program. The first Energy Improvement Loan Program document package was completed and mailed to Franklin Health and Fitness for signature. Once all documents are signed by DOA and the client, they will be the first executed loan since the expansion of the Loan Program to include local government and non-profits.

- **SEP Exec-14:** The State Energy Office should develop programs, in addition to weatherization, to address energy-efficient housing in the low-income sector. The State Energy Office should investigate technologies, incentives, financing options, and regulatory issues regarding minimum efficiency requirements for manufactured housing and promote ENERGY STAR manufactured homes.

  The SEO formed the Low-Income Residential Energy Program (LIREP), initially focusing on new construction in manufactured homes (MH) and with public housing authorities. The original target audience of Greenville Utilities service area customers included Greenville and approximately 80% of Pitt County. Subsidy money (up to $500/home) will be paid to the local MH retailers who equip the customer's new homes

with high-efficiency heat-pumps as the primary heating system instead of electric-resistance furnaces. This contract has been completed. LIREP's Upgrade & Save Program, operated by East Carolina University, has been expanded to include MH retailers and potential new home buyers in Pitt and sixteen surrounding counties of Beaufort, Bertie, Carteret, Craven, Duplin, Edgecombe, Greene, Halifax, Jones, Lenoir, Martin, Nash, Onslow, Pamlico, Wilson &.Wayne. Subsidies are paid to the MH retailers who sell heat pump-upgraded homes. The program has active involvement from 37 MH retailers and HVAC distributors/suppliers in the local areas. The program offers "retrofit" assistance (50% of the cost, up to $1,500) to area MH owners who purchased homes manufactured since 1/1/1998 and before 1/1/2004. Through June, 2005, over 100 manufactured homes have been upgraded to heat pumps. We are working with Eastern Carolina University to expand "Upgrade & Save" to additional eastern NC counties next year. The SEO is partnering with the National Association of Energy Service Companies in a US DOE Special Project contract to work closely with three North Carolina Public Housing Authorities (PHAs) to use performance contracting to finance energy efficiency measures in existing PHA units. This process will save energy when renovating aging housing and equipment. The project provides training, development of a template RFP, and technical assistance from the SEO. SEO is working with Advanced Energy to ensure energy efficient construction in several PHA projects. The new units will be built to high efficiency levels so that residents are offered guaranteed low monthly utility bills. Two prospective locations have not moved forward due to holdup of HUD (Housing and Urban Development) Section 8 funding and permitting concerns. Five other locations are in negotiation. SEO's LIREP project with Mountain Housing Opportunities in Asheville is complete. The 15-unit development, which consists of single family and multi-family structures, utilizes energy-efficient sustainable construction. High efficiency heat pumps and solar water heating were incorporated in the revitalization of this existing community. All structures conformed to the NCSC's HBH standards. Total annual energy savings of 60,760 kWh or $5,165 are anticipated. Water use reduction measures are expected to save 74,000 gallons annually. Annual pollution reductions of 84,856 lb. in CO_2, 4,557 lb. in SO_2 and 369 lb. in NO_x are expected.

An LIREP contract with Metropolitan Housing & Community Development Corporation in Washington, NC, for 36 low income energy-efficient homes, has been approved. Construction on the units has begun. An RFP to solicit potential projects for the remaining funding under the LIREP will be issued in 2006. The "Renewable Energy Project in New Affordable Homes in Western North Carolina," conducted by ASU, is near completion. This project is intended to increase the use of renewable energy technologies in residential construction, especially in affordable housing. A passive solar home plan books for affordable housing is complete. The project provided design/installation assistance for construction of a Zero Energy Home (ZEH). The ZEH, built by the local Habitat for Humanity chapter in Hickory, is completed. It features a ground-source heat pump, photovoltaic panels, passive solar design and solar water heating. The new Consumer Energy Education program was launched with NCSU's Cooperative Extension Service. Under this program, 3 pilot counties (Buncombe, Orange, Edgecombe) will present consumer and extension agent training and schedule 100 energy audits for consumers to educate homeowners about energy efficiency and ways to save money and energy. Three workshops have been scheduled; bids from energy auditors

have been received and the program manager, to be based at NCSU has been recommended for hire. Southface-North Carolina Office, under an SEO Special Projects contract, developed informational placards to be placed in high performance homes, including high performance homes for the low income sector. The placards address topics including: improved insulation; air sealing; duct sealing; low-e windows; compact fluorescent lamps; appliances; balanced ventilation; and ENERGY STAR Homes.

- **SEP Exec-20:** The State Energy Office should organize a statewide effort to develop criteria for a residential high performance building program to reduce the life cycle cost of new and existing buildings. The criteria should utilize provisions from other successful high performance programs, including ENERGY STAR, programs developed by Advanced Energy Corporation, NC Healthy Built Homes, Southface Energy Institute's Earthcraft Home Program, US DOE's Building America program, and others. As a result of our residential energy-efficiency "umbrella" promotion initiative, SEO and ASU has launched an NC ENERGY STAR Web site; http://www.ncenergystar.org. Through collaboration with representatives of utilities and other organizations who market energy-efficiency housing programs across the state, the SEO will promote all of the current residential energy-efficient programs which meet or exceed the ENERGY STAR standards. An ENERGY STAR Conference is scheduled for December, 2005. A contract, with the Residential Energy Services Network (RESNET), that is intended to promote energy efficient construction and energy efficient mortgages in NC is in the DOA approval process. RESNET will partner with Wachovia Mortgage, Countrywide Home Loans and Fannie Mae to deliver this project.

- **SEP Exec-15:** The General Assembly should review options, such as a Public Benefits Fund (PBF) or other means, to enable funding of the recommendations in the State Energy Plan. A report was prepared by ASUEC on evolution of PBFs in other states and presented to the Council on November 20, 2003. ASU developed a PBF economic analysis model with input from several economists. An evaluation by US DOE's National Renewable Energy Laboratory (NREL) will be presented to the Council on March 31, 2005.

- **SEP Exec-20:** The State Energy Office should organize a statewide effort to develop criteria for a residential high performance building program to reduce the life cycle cost of new and existing buildings. The criteria should utilize provisions from other successful high performance programs, including ENERGY STAR, programs developed by Advanced Energy Corporation, NC HBH, Southface Energy Institute's Earthcraft Home Program, US DOE's Building America program, and others. As a result of our residential energy-efficiency "umbrella" promotion initiative, SEO and ASU have launched an NC ENERGY STAR Web site; http://www.ncenergystar.org. Through collaboration with representatives of utilities and other organizations who market energy-efficiency housing programs across the state, the SEO will promote all of the current residential energy-efficient programs which meet or exceed the ENERGY STAR standards. An ENERGY STAR Conference is scheduled for December 2005. A contract with the RESNET that is intended to promote energy efficient construction and energy efficient mortgages in NC is in the DOA approval process. RESNET will partner with Wachovia Mortgage, Countrywide Home Loans and Fannie Mae to deliver this project.

- **SEP 4-1:** The North Carolina Utilities Commission is encouraged to promote policies that create diversity in energy supply such as natural gas, solar energy, wind energy, biomass, and hydrogen from renewable sources with particular emphasis on in-state energy development. Technical discussions regarding an interconnection policy that details liability, hardware, and rate issues have taken place under facilitation from the NCSC. A detailed docket brief describing these issues has been filed with the North Carolina Utilities Commission (NCUC) in August 2004. The NCUC annually reviews fuel diversity in generation as a factor of the integrated resource planning process. In addition, the NCUC continues to encourage and support participation in NC GreenPower, a statewide effort to develop renewable generation in NC. NC GreenPower has announced contracts with a number of solar and biomass facilities in the state. A biomass assessment project has been completed by NC A&T State University. This project characterized crop residues and forest wastes to determine energy content and amount of waste generated and available for use.
- **SEP 4-5:** Because the December 2002, ice storm raised public interest in use of distributed generation (i.e., in facilities used as public shelters, residential housing, etc.), the State Energy Office should study distributed generation and appropriate applications. The Center for Energy Research and Technology conducted four Distributed Generation Workshops: in Greensboro on October 28, 2003, in Flat Rock on March 30, 2004, in Wilmington on June 16, 2004, and in Charlotte on June 18, 2004.
- **SEP 5-4:** The State Energy Office, Department of Agriculture, and DENR should support landfill methane gas projects through direct grants and loans based on need, as well as technical assistance. A landfill gas steering committee, formed as a result of the first NC Biomass Conference, has identified landfill gas development barriers and strategies, and held a statewide landfill gas conference for December 10, 2004. As follow-up to the conference the landfill gas committee has met with NCUC Public Staff to address regulatory concerns relative to developing landfill gas opportunities. SEO continues to support landfill gas projects with four active projects (Avery, Wilkes, Jackson, and Watauga Counties). Also, technical support is being provided to assess feasibility of sites in Wilson and Wayne Counties and in the City of Durham. An earlier project at Yancey-Mitchell landfill has successfully used energy from the landfill for operation of buildings, greenhouse, kiln, and glass-blowing facilities.
- **SEP 6-1:** A Solar Schools Program should be developed and incorporate renewable electricity generation, solar water heating, and daylighting to reduce fossil fuel use by schools, improve the quality of education, provide a real-world energy training lab, and make our citizens more aware of the potential for renewable resources. The SEO will fund the NEED Project's Schools Going Solar program in North Carolina. A total of six PV systems will be installed: five will be grid-tied, while the sixth will be a battery backup, PV-assisted uninterruptible power supply (UPS) system. This program allows schools to receive photovoltaic installations and solar energy curriculum and training programs to facilitate an understanding of solar energy and its diverse applications. With teacher training, student materials, and the installation of a learning lab, these schools learn about renewable energy, nonrenewable energy, and the impact that energy use has on economics and the environment.

- **SEP 6-2:** The State Energy Office should work with the state's professional licensing boards to develop a certification program for renewable energy installers. The NCSC is a participant in the national PV installer training program that will result in certification of installers. The NC HBH program is developing training workshops for builders. The Renewable Energy Diploma Series is now offering classes through NCSU covering renewable energy technology. These classes include field installation activities.
- **SEP 7-1:** North Carolina statutes should require that designers of all new public buildings provide estimates of projected energy consumption and energy costs for the building prior to construction. A beginning point for required estimation of whole building energy use was made through 2001 Session HB (House Bill) 1272. This legislation requires state agencies to use life cycle cost analysis over the economic life of the facility in selecting the optimum systems in constructing or renovating any *state* facility. The ASUEC is preparing an analysis of a sampling of state buildings approved since passage of this requirement.
- **SEP 7-3:** The North Carolina Department of Administration should implement high performance building guidelines developed for North Carolina in all new public buildings and also develop and implement high performance guidelines for new public housing. A pilot program to evaluate state buildings constructed to High Performance Building Guidelines is underway.
- **SEP 7-4:** The North Carolina Department of Administration should develop performance contracting procedures and other ways to finance energy efficiency projects for state and local governments, university and public school systems, and public housing. The Department of Administration should provide technical support to implement performance contracting projects and provide quality assurance. The SEO has developed a standard template RFP and contract templates, as well as procedures, for performance contracting. The SEO and State Construction Office have developed a scope of work for the Museum of Art project and for a downtown government complex project. SEO has been providing technical assistance to universities, state agencies, K-12 schools and community colleges which are evaluating potential performance contracting projects.
- **SEP 7-5:** State agencies should lead by example by establishing a certain minimum level of electricity to be derived from renewable sources, such as the North Carolina GreenPower Program, or via installation of state-owned renewable energy projects. The SEO is buying the equivalent of 100% of its annual electrical load from North Carolina GreenPower (NCGP). DENR is investigating options for NCGP purchase. A meeting was held with the State Budget Office to request clearance for state agencies to participate in the NC GreenPower Program.
- **SEP 7-6:** North Carolina Department of Administration should require that all state facilities with motors larger than 5 horsepower must develop a motor maintenance program. Under the Utility Savings Initiative program, a motor maintenance program is under development with consultation from Advanced Energy Corporation and NCSU Industrial Extension personnel, as well as research into current and best practices.
- **SEP 7-7:** Local governments should be encouraged to implement the above actions and other energy efficiency programs. Through the EnergySmart Schools Initiative, NEED

has delivered three conferences targeted towards school administrators, school business officials, school board members, energy and facilities managers, and curriculum directors to provide information on the best practices found in school districts and resources that the SEO and others can provide to K-12 schools to reduce energy costs. Local governments and schools have been invited and welcomed at a variety of USI training sessions, including five performance contracting workshops and the latest Energy Management Diploma series. Working with DPI, three strategic energy planning workshops were held for K-12 officials. Under USI, a coordinator position will be jointly funded for 05-06 for the Community College system to target 6 pilot colleges for a comprehensive energy efficiency program. A similar arrangement is proposed for DPI. On February 23, 2005, SEO staff members met with the Local Government Commission to encourage the implementation of energy efficiency, renewable and recycling projects by taking advantage of the Energy Improvement Loan Program.

- **SEP 8-1:** The State Energy Office should conduct a study on current compliance levels of residential and commercial buildings with the North Carolina state energy code. The study should make recommendations for improvements in compliance procedures and for energy code changes that are in the best interests of the state. ASUEC surveyed a small sample of 30 recently constructed average residences to determine relative energy efficiency. Blower door, duct leakage tests, and other data were used to rate the energy performance of the homes. Some homes did not meet state energy code and none meet the preferred ENERGY STAR standard. Southface Energy Institute has also conducted energy analysis of newly constructed western NC homes. Energy simulation software was used to estimate the energy savings which would develop from improved energy codes and increased stringency of enforcement of codes. The energy analysis will also determine whether additional expenditures and resources to improve both the quality of the energy codes and their enforcement are justified. Over the upcoming nine months, ASUEC will analyze 20 additional homes using this software.
- **SEP 8-2:** The State Energy Office should create an Energy Code Enforcement Assistance Program to provide additional energy code enforcement and outreach officials to serve across the state. The state should consider whether adding a state surcharge on all local building permit fees to support the program is feasible. The SEO is planning an initial meeting with representatives from the Department of Insurance and Southface Energy Institute to discuss the enforcement of energy codes throughout the state. SEO contracted with Southface Energy Institute to lead training workshops on building code standards for inspectors in 2004. Eight workshops have been conducted in 2003 and 2004 in four locations around the state. Over 170 persons attended the workshops. Training was also provided to 6 special groups and organizations including the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE), affordable home representatives, and American Institute of Architects (AIA) chapters. Southface Energy Institute–North Carolina Office continues to meet and work with the Department of Insurance to develop and implement the enforcement of energy codes throughout the state.
- **SEP 8-3:** At a minimum, the State Energy Office should encourage new manufactured homes to comply with the critical components of the state energy code for site-built residential units and promote ENERGY STAR manufactured homes. The program should

include a comprehensive statewide training program on the benefits and details of higher efficiency units. The Center for Energy Research and Technology at NC A&T State University continues its work with manufactured housing. Palm Harbor Homes and Oakwood Homes provided testimonials confirming that the research at NC A&T State University has caused them to produce manufactured homes that save 25% more energy than the regular HUD-built home. The Manufactured Housing Institute also supplied testimonials about the importance of Community Emergency Response Team's (CERT's) research for the manufactured housing sector. The Center for Energy Research and Technology at NC A&T State University is investigating various seer levels energy efficiency heat pumps for manufactured housing. They expect to obtain energy usage data which will be provided to manufactured housing manufacturers, retailers, advocacy groups, utilities and research organizations. In addition, they are planning developing training classes for the set-up contractors who site manufactured homes. East Carolina University's Upgrade & Save Program-Heat Pumps in Manufactured Homes has been expanded to include MH retailers and potential new home buyers in Pitt and sixteen surrounding counties of Beaufort, Bertie, Carteret, Craven, Duplin, Edgecombe, Greene, Halifax, Jones, Lenoir, Martin, Nash, Onslow, Pamlico, Wilson & Wayne. Subsidies are paid to the MH retailers who sell heat pump-upgraded homes. Thirty-seven MH retailers and several HVAC distributors/suppliers in the local are actively involved in this program. As of June, 2005, over 100 manufactured homes have been upgraded to heat pumps. We are working with Eastern Carolina University to expand "Upgrade & Save" to additional eastern NC counties next year. SEO and NC Cooperative Extension Service will provide consumer training on energy measures.

- **SEP 8-5:** The State Energy Office should develop a comprehensive, statewide promotional campaign for high performance buildings. The SEO is continuing its efforts to develop a statewide promotion of residential energy efficient/ENERGY STAR construction through a committee of stakeholders/interested parties that was formed in the 2nd quarter of 2004. Jeff Tiller (ASU) serves as Chairperson along with representatives of ENERGY STAR, Progress Energy, the Electric Membership Cooperatives, Duke Power, Greenville Utilities, Advanced Energy, the NCSC and SEO staff. Several meetings have been held and agreement was reached on a promotional initiative that includes an online NC ENERGY STAR Web site. An ENERGY STAR Conference will be held in December 2005.

- **SEP 8-6:** The State Energy Office should continue its work to formulate and advance mortgage-based incentives for high performance new homes. In 2004, the SEO partnered with RESNET, Fannie Mae, Countrywide and Wachovia to promote the Energy Efficient Mortgage (EEM) Initiative. EEM Media events were held in Raleigh, Charlotte, Asheville, Wilmington, and Winston-Salem. The EEM recognizes lower operating costs of energy efficient homes and higher home values when homes are energy efficient. The EEM will increase affordability for home buyers, regardless of income, and encourage energy efficient housing in NC. In addition, the program has boosted the number of ENERGY STAR-labeled homes built in NC. A new contract with the RESNET is in the DOA approval process. It is intended to continue the promotion of energy efficient/ENERGY STAR residential construction and energy efficient mortgages in NC.

RESNET plans to add more lending partners to its existing group of Wachovia Mortgage, Countrywide Home Loans and Fannie Mae.

- **SEP 8-7:** The State Energy Office should provide training on high performance buildings to builders, subcontractors, architects and engineers, landscape architects, code enforcement officials, utility representatives, building investors, developers, financial institutions, real estate professionals, appraisers, home inspectors, renovation contractors, educators, and prospective homeowners. NCSC holds workshops on building design strategies that promote sustainable design principles. The HBH Program is actively reaching out to builder organizations and has marketing incentives for builders who build to HBH standards. RESNET provided high-performance building marketing training for utility representatives, appraisers and home energy raters in November, 2003, in Raleigh.
- **SEP 8-8:** The State Energy Office should provide training for building professionals on specific targeted technologies including residential daylighting, solar water heating, heat pump water heaters, new insulation products, and advanced HVAC systems and controls. NCSC holds workshops on renewable energy technologies for building professionals. ASU provided training in new technologies to affordable housing and solar industry representatives. A workshop on performance contracting for PHAs is scheduled for October 2004. As a part of its educational outreach, Mountain Housing Opportunities, Inc. held an open house that showcased its "Green Building Demonstration" sustainable building project. They also partnered with NC HBH, Asheville area home builders and the local Green Building Council to offer informational tours of this 15-unit low-income, green housing development. Sustainable building concepts and products, such as passive solar design, solar water heating and environmentally friendly products, are included in the project.
- **SEP 9-1:** The State Energy Office should work with appropriate state agencies to provide a design review service that focuses on energy-efficient components and holistic, high-performance, design strategies for new commercial buildings. The design review procedure should include a systematic life cycle cost analysis of a variety of energy technologies and strategies for each project. The service should seek to upgrade new buildings to meet high performance building guidelines developed statewide. The NCSC is conducting a limited number of commercial design reviews that focus on addressing Leadership in Energy and Environmental Design (LEED) requirements and objectives.
- **SEP 9-2:** The State Energy Office should promote and develop guidelines for performance contracts, conduct workshops, and provide technical assistance on developing performance contracting documents. The SEO, in conjunction with the State Construction Office and the Attorney General's Office, has completed a template RFP for use by all state agencies and universities engaged in performance contracting. Template contract documents have received final review by the Attorney General's Office. Currently, ASU, UNCG, NC A&T State University, DOA, and the North Carolina Department of Commerce (DOC) are developing projects.
- **SEP 9-4:** The State Energy Office should promote the use of and provide training for commercial building energy analysis software to assist building owners with evaluating the best energy efficiency measures to implement in existing state buildings and other commercial structures. SEO partnered with Southface Energy Institute to conduct eight

Commercial Energy Codes training workshops. During the workshops, 180 attendees learned about US DOE's commercial energy code software, COMcheck-EZ Software and the COMcheck Prescriptive Packages. Workshops were held in Raleigh, Nags Head, Chapel Hill, and Charlotte.

- **SEP 9-5:** The State Energy Office should develop an energy audit program for existing commercial buildings to assist building managers with implementing the most energy efficient and cost effective improvements for commercial renovation projects. SEO contracted with Waste Reduction Partners to design a Self-Assessment Guide for Energy-Saving Opportunities for use by organizations ranging from nonprofits to businesses to public institutions. The guide helps establish priorities and identify measures to be taken. Copies of the guide are available from SEO or Land-of-Sky COG or can be downloaded from SEO's Web site.
- **SEP 10-3:** North Carolina should evaluate whether facilities that repair or rewind motors should be certified or otherwise meet a state efficiency requirement. Through USI training, SEO promotes the use of Motor Master Plus software available free from US DOE to evaluate replacement with premium efficiency motors instead of rewinding motors. NCSU Industrial Extension Service (IES) also offers motor efficiency workshops.
- **SEP 10-5:** North Carolina should create investment tax credits and other incentives for new and/or retrofitted manufacturing equipment to encourage modernization and efficiency improvements.
- **SEP 10-8:** North Carolina should create policies and regulations for distributed generation in the state, including incentives for deployment of "clean" distributed generation. After a collaborative process encouraged by the NCUC, investor-owned utilities jointly filed Docket No. E-100, Sub 101 on June 4, 2004, which included model small generation interconnection standards, associated application to interconnect, and interconnection contract forms. On July 12, 2004, the NCUC issued an order allowing interested persons to intervene in this docket and to file written comments or reply comments. Initial comments were filed by the Attorney General and the NC Sustainable Energy Association. Reply comments are due to be filed by September 24, 2004. The SEO has a lead role in the Southeast CHP Applications Center and the NC CHP (Cooling, Heating, and Power) Center. Both are working to advance distributed generation systems.
- **SEP 10-9:** The State Energy Office should sponsor workshops on industrial energy efficiency around the state directed at industrial facility operators, design and process engineers, and owners. The workshops will describe the state-of-the-art in efficient technologies and describe the results of ongoing research efforts. The training effort should also address water-conserving practices around the state. Through the Industrial Extension Service, the Energy Management Program provides workshops on industrial energy efficiency throughout the year. Workshops are conducted on the following areas: air compressors, chillers and cooling towers, energy efficient lighting, energy efficient motors and variable speed drives (VSDs), HVAC, boilers, preventive maintenance, steam traps, and steam systems.

- **SEP 12-1:** The State Energy Office should develop and sponsor training programs for community colleges and universities in fields related to energy efficiency and high performance buildings. Technical support is being provided to Wilson Tech and a commercial landfill gas company in an effort to use landfill gas at the college and also generate a training curriculum on landfill gas generation and application. A-B Tech is being provided with technical support to train community colleges in energy management and performance contracting.
- **SEP 12-2:** The State Energy Office should assist in the coordination of energy education programs with museums and help create an energy museum "on wheels" using existing resources, such as the Science House at NCSU or the Museum of Life Science, wherever possible. The EV (Electric Vehicle) Challenge program utilizes a mobile classroom with exhibits, video, and a red Spitfire (converted from gasoline engine to electric battery) for presentations to high schools across the state.
- **SEP 12-3:** The State Energy Office should sponsor regional "renewable demonstration centers" or, whenever possible, use existing ones (e.g., demonstration centers such as the North Carolina Solar House and the EnergyXchange, museums such as the Museum of Life and Science, Discovery Place). The alternative fuel vehicle demonstration facility at the NCSC is developing new displays to highlight the range of alternative fuels that can be produced. Negotiations are underway with the Museum of Natural Science regarding a renewable energy demonstration.
- **SEP 12-4:** The State Energy Office should create energy internships or apprenticeships for graduating college students and high school students to create the next generation of energy professionals. The SEO has had three interns through the Youth Advocacy & Involvement Office and two volunteers who assisted with special projects for the staff. A verbal agreement has been made with Duke University's Nicholas School of the Environment to support up to four graduate work/study students for a full school year on energy/environmental projects. An energy management student intern will be funded under USI for UNC Asheville for the year 2005-2006.
- **SEP 12-5:** The State Energy Office should provide a statewide award (e.g., a college scholarship) for the most outstanding energy-related science demonstration/experiment at the state science fair.
- **SEP 12-6:** The State Energy Office and the UNC System should help the Education Departments of colleges and universities develop coursework for junior and senior undergraduates and graduate students in energy education. SEO programs include the Model Solar Fuel Cell Cars project which takes air quality and alternative fuels information to middle school students. An annual competition includes several categories with the overall championship team rewarded with a trip to the national event to represent the state. Several SEO-sponsored programs train current K-12 teachers in energy and environmental issues. These include NEED, EV Challenge, Junior Solar Sprint, and Model Solar Fuel Cell Cars.
- **SEP 12-7:** The State Energy Office and the state's colleges and universities should help Community Colleges and other vocational schools develop coursework in energy efficiency and renewable energy to help spur the industry; such as training carpentry

students in energy efficient, passive solar building design and construction. Include this training in vocational -technical courses in high schools. Technical support is being provided to Wilson Tech and a commercial landfill gas company in an effort to use landfill gas at the college and also generate a training curriculum on landfill gas generation and application. A-B Tech is being provided with technical support from the SEO to train community colleges in energy management and performance contracting.

- **SEP 12-8:** The State Energy Office should provide training to licensed professionals in the homebuilding industry focusing on energy efficiency and renewable energy sources to promote industry awareness and implementation of these technologies. A range of workshops is offered by the NCSC on green building topics including; green building, passive solar design, photovoltaics, solar hot water technology, and energy calculations. The HBH program conducts workshops on green building and provides marketing incentives for builders to incorporate green building practices. Southface conducted Residential and Commercial Energy Code workshops in Nags Head, Chapel Hill, Charlotte, and Raleigh. High Performance Home Workshops were held in Greenville, Raleigh, and Charlotte. RESNET conducted a North Carolina Energy Rater Training Workshop in Raleigh.

- **SEP 12-9:** The State Energy Office should support development of a comprehensive information outreach program for consumer questions about saving energy and using renewables in their homes and businesses; information hotline via a toll-free telephone number; informative Web page containing a wide array of publications available on-line; resources that include up-to-date information on renewables and energy efficient buildings, industrial facilities, and vehicles, as well as data on energy sources in the state; information on energy-producing facilities; environmental information related to energy consumption; and other energy-related information. Brief fact sheets to address energy conservation and efficiency issues have been prepared by Waste Reduction Partners. Topics include vending machines, upgrading to T-8 fluorescent lamps, occupancy sensors, computer monitors, drinking fountains and water coolers, and task lighting. Several additional topics are being developed. This information will be helpful to energy managers in a variety of buildings, whether state-owned, K-12 schools, local government, or commercial. An energy conference, accessible to all sectors and audiences seeking energy-related information, was held in March 2004 and will be held annually in the future. The SEO will broaden its efforts in public education to include a series of consumer-oriented trainings to be conducted through the NC Cooperative Extension Service. Extension agents will be trained and offer training to consumers about home energy efficiency. Outreach tools also include distribution of energy kits to consumers and professional energy audits in pilot counties. In our efforts to continue promoting all of the current residential energy-efficient programs which meet or exceed the ENERGY STAR standards, the SEO and ASU have launched an NC ENERGY STAR Web site: http://www.ncenergystar.org. The NC ENERGY STAR Web site, which is accessible from our own SEO Web site, offers information and links to utilities and other organizations who market energy-efficiency housing programs across the state.

- **SEP 12-10:** North Carolina should encourage schools to reduce school operating budgets by installing energy efficiency and renewable energy systems. NEED Smart Schools and energy education workshops for K-12 officials were held in Asheville, Chapel Hill, and

Wilmington. SEO and DPI held Strategic Energy Planning workshops in four locations for K-12 officials.

- **SEP 12-12:** The State Energy Office should work in partnership with the State DPI to plan school energy-related initiatives and include a representative for energy-use in school facilities on the Energy Policy Council.
- **SEP 12-14:** The State Energy Office should sponsor a program to install solar equipment or other sustainable energy technologies on school buildings in every school district in the state. NEED has been awarded a contract to install photovoltaic systems on six schools in NC. There are also 6 solar charging stations operating at high schools in NC. These charging stations operate in conjunction with the EV Challenge program and provide solar charging of electric cars. Demonstration water source heat pumps have been successfully tested on mobile classroom units by NCSU. In addition, a high performance mobile classroom is being monitored for performance by the NCSC. Both projects have potential for replication in many schools. SEO will fund the NEED Project's Schools Going Solar program in North Carolina. A total of six systems will be installed. Five will be grid-tied while the sixth will be a battery-backup, PV-assisted UPS system.
- **SEP 12-15:** The North Carolina Community College System should require that the community colleges' curricula provide a building science course, an energy design course for drafting programs, and a solar/renewable energy technology class. The SEO provided technical assistance to Wilson Tech and A-B Tech in design of curriculum for efficiency and renewable energy areas.
- **SEP 12-16:** The State Energy Office should establish a central repository for energy information. This energy data and policy analysis center should develop baseline information on energy consumption by state and local governmental entities. The center should also provide policy analysis for existing and proposed state energy policies. A database has been created to record summary utility use and cost data for state agencies and universities. The SEO is also working with the Department of Correction to track utility use, costs and inmate populations and square feet of building space with a Web-based utility accounting program. Plans are underway to create an integrated database to house information from other agencies.

ANNEX B TO RCI Mitigation Option Recommendations

Printouts of Selected Portions of Worksheets Used to Prepare Estimates of Costs and Benefits of Residential, Commercial, and Industrial Mitigation Options

Printouts below reflect status of analyses as of June 6, 2007

Estimate of Mitigation Option Costs and Benefits for North Carolina RCI GHG Analysis

Common Assumptions for North Carolina RCI GHG Analysis

Date Last Modified: 5/31/2007 D. Von Hippel/A Bailie

Common Assumptions

Real Discount Rate	**5%**	
Levelized, Avoided Costs (2006-2020, 2005$)		
Electricity - Sales-Weighted Average	**$57**	$/MWh
Derived from rates for Qualifying Facilities from Duke Power, Progress Energy, and Dominion Resource Services. See "AvCost" worksheet in this workbook.		
Electricity - Residential	**$57**	$/MWh
Electricity - Commercial	**$57**	$/MWh
Electricity - Industrial	**$57**	$/MWh
Levelized Costs not differentiated by sector for this analysis.		
Natural Gas	**$8.0**	$/MMBtu
Note: In the absence (as of 12/12/06) of NC-specific avoided gas costs, we derive a placeholder estimate for NC avoided gas costs by starting with average 2005 NC citygate gas costs and escalating costs based on escalation in weighted-average regional AES2006 estimates for gas cost by sector. These values should be replaced by NC-specific costs when and if available.		
Prices		
Electricity Price - Sales-Weighted, Levelized	**$66**	$/MWh
Prices are based on DOE data for prices in 2005 http://www.eia.doe.gov/cneaf/electricity/esr/esr_sum.html. Changes from 2006 to 2020 are based on the relative changes in projected SERC reliability Corporation region prices in US DOE Annual Energy Outlook 2006 (same % changes). AEO 2006 projects prices to declining to below 2005 levels from 2008 onward.		
Electricity - Residential Prices (Levelized, 2006-2020)	**$77**	$/MWh
Electricity - Commercial Prices (Levelized, 2006-2020)	**$63**	$/MWh
Electricity - Industrial Prices (Levelized, 2006-2020)	**$47**	$/MWh
Natural Gas (Delivered, RCI sales-weighted average)	**$10.2**	$/MMBtu
Natural gas prices are estimated as described for electricity above.		
Natural Gas - Residential Prices (Levelized, 2006-2020)	**$12.6**	$/MMBtu
Natural Gas - Commercial Prices (Levelized, 2006-2020)	**$10.2**	$/MMBtu
Natural Gas - IndustrialPrices (Levelized, 2006-2020)	**$7.5**	$/MMBtu
Biomass - All Users	**$2.4**	$/MMBtu
Estimate based on national study of state-by-state biomass resource resource assessments--see worksheet "Biomass_Data" in this workbook. Price equivalent of $38/dry ton at 16 MMBtu/dry ton. Replace with more NC-specific estimates (for example, from AF group when available).		
Coal - Industrial Users	**$2.4**	$/MMBtu
average coal heat content of 26.75 MMBTU/ton, based on 2001 USDOE/EIA data. USDOE/EIA figures for 2005 from suggest NC average coal price of $65.25 per ton for coal for "Other Industrial Users". www.eia.doe.gov/cneaf/coal/page/acr/table34.html		
Oil - Distillate/Diesel	**$13.4**	$/MMBtu
USDOE/EIA data gives NC average prices for heating oil of $1.846 per gallon in 2005/06 heating season. This cost does not include fuel taxes. An appendix to the 2006 Annual Energy Outlook by USDOE/EIA (see http://www.eia.doe.gov/oiaf/aeo/pdf/appendixes.pdf) lists an energy content for distillate oil of 5.799 MMBtu/bbl, or 0.138 MMBtu/gallon.		
LPG	**$12.3**	$/MMBtu
USDOE/EIA data gives NC average prices for propane of $1.846 per gallon in 2005/06 heating season. This cost does not include fuel taxes. Prices expressed on $/MMBtu basis a conversion factor of 0.09133 MMBtu/gallon (see "Fuel Data" woksheet)		
Landfill Gas - All Users	**$5.0**	$/MMBtu
Placeholder Estimate		
Biogas Gas - All Users	**$5.0**	$/MMBtu
Placeholder Estimate		

Emission Rates, etc.	2010	2020	Units
Electricity T&D losses (fraction of total generation)	6.0%	5.6%	

Pasted from (not linked to) updated ("Revised GHG forecast - version 1.2.xls") inventory and forecast, and as used in Energy Supply options analysis (row 543 of "Assumptions (revised)" worksheet).

Avoided electricity emissions rate	0.880	0.713	tCO_2/MWh

Assumes that reductions in electricity generation requirements through 2010 will come from the average emissions rate of then-existing fossil-fueled sources; by 2020 the predominant effect is assumed to be a reduction in reference case new coal and gas builds during the 2010-2020 period.

Notes	2010	2020	Units

Multi-Gas Emission Factors

Except as noted, the following emission factors are calculated from values in the North Carolina Inventory and Forecast prepared for the CAPAG, and reflect the average emissions in 2000 per BTU and physical amount of fuel. They include combustion CH4 and N20 as well as CO2 emissions for consistency with the inventory.

	tCO_2e/billion BTU	
LPG - RCI	63.425	assumed equal to CO_2 factor for propane
Coal - RCI	92.961	
Natural Gas - RCI	52.071	
Biomass - RCI	2.793	
Oil - RCI	74.342	assumed equal to CO_2 factor for misc pet prods
Landfill Gas - RCI	0.260	

As suggested by CAPAG Agriculture, Forestry and Waste TWG. This value excludes benefits from capture and use of methane that would have escaped from landfills, as those benefits are captured in the AFW TWG analysis.

Biogas - RCI	0.260	*Placeholder Value--assumed same as landfill gas for now--May in fact be negative*

GDP Deflators (to 2005$)

Cost Year	Index
1997	1.18
1998	1.16
1999	1.15
2000	1.12
2001	1.09
2002	1.08
2003	1.05
2004	1.03
2005	1.00

Natural Gas Conversion	1.03	million Btu/ thousand cf
Electricity Conversion	3413	MMBTU/ GWh

Estimate of Mitigation Option Costs and Benefits for North Carolina RCI GHG Analysis

GHG Emissions Totals for North Carolina RCI GHG Analysis

Date Last Modified:	*9/12/2007*	*D. Von Hippel/A Bailie*

Summary Results and Totals for RCI Mitigation Options

	Option Name	GHG Reductions ($MMtCO_2e$) 2010	GHG Reductions ($MMtCO_2e$) 2020	Cost-Eff ($/$tCO_2e$)	NPV 2007-2020 ($million)	Cumulative Emissions Reductions (MMt CO_2e, 2007-2020)	
RCI-1	Demand Side Management Programs for the Residential, Commercial and Industrial Sectors --Recommended Case: "Top-ten States" EE Investment	1.9	11.6	-$25	-$1,895	77.1	RCI-1
RCI-2	Expand Energy Efficiency Funds	1.5	8.0	-$25	-$1,346	54.8	RCI-2
RCI-3	Energy Efficiency Requirements for Government Buildings	0.0	1.1	-$14	-$88	6.4	RCI-3
RCI-4	Market Transformation and Technology Development Programs	0.0	2.0	-$32	-$339	10.5	RCI-4
RCI-5	Improved Appliance and Equipment Efficiency Standards	0.0	1.0	-$63	-$336	5.3	RCI-5
RCI-6	Building Energy Codes	0.5	3.5	-$17	-$400	23.1	RCI-6
RCI-7	"Beyond Code" Building Design Incentives and Targets, Incorporating Local Building Materials and Advanced Construction	0.7	5.2	-$14	-$494	34.2	RCI-7
RCI-8	Education (Consumer, Primary/Secondary, Post-Secondary/ Specialist, College and University Programs)	Not Quantified					RCI-8
RCI-9	Green Power Purchasing (required for state facilities) and Bulk Purchasing Programs for Energy Efficiency or Other Equipment	0.1	0.5	$3	$11	3.5	RCI-9
RCI-10	Distributed Renewable and Clean Fossil Fuel Power Generation	1.2	4.6	$12	$392	33.5	RCI-10
RCI-11	Residential, Commercial, and Industrial Energy and Emissions Technical Assistance and Recommended Measure Implementation	0.5	2.1	-$33	-$494	14.9	RCI-11
	Total Gross Savings with RCI-1 Recommended Case	6.4	39.7	-$19	-$4,990	263.3	Total of Options

Adjustment for Estimated Overlap Between RCI Options						
Overlap between RCI Options with RCI-1 Recommended Case: "Top-ten States" EE Investment						
RCI-2, Overlap with RCI-1	0.5	2.41		-$404	16.4	***See Note 2***
RCI-3, Overlap with RCI-1 and RCI-2	0.0	0.23		-$18	1.3	***See Note 3***
RCI-4, Overlap with RCI-1 through RCI-3	0.0	0.41		-$68	2.1	***See Note 4***
RCI-5 Overlap with RCI-1 through RCI-4	0.0	0.00		$0	0.0	***See Note 5***
RCI-6 Overlap with RCI-1 through RCI-5	0.0	0.0		$0	0.0	***See Note 5***
RCI-7, Overlap with RCI-1 through RCI-6	0.3	2.6		-$247	17.1	***See Note 6***
RC-9, Overlap with Other Quantified Policies	0.0	0.1		-$13	0.2	***See Note 7***
RCI-10 Overlap with Other Quantified Policies	0.0	0.0		$0	0.0	***See Note 8***
RCI-11 Overlap with Other Quantified Policies	0.3	1.0		-$247	7.5	***See Note 9***
Total Estimated Overlap Among RCI Policies (RCI-1 Case 2)	1.06	6.73		-$997	44.6	
Total Savings Net of Overlaps with RCI-1 Recommended Case	5.3	33.0	-$18	-$3,994	218.7	

Additional Emissions Savings from Recent Actions (not included in forecast or in policy options above)

	Option Name	GHG Reductions ($MMtCO_2e$) 2010	GHG Reductions ($MMtCO_2e$) 2020		Cumulative Emissions Reductions (MMt CO_2e, 2007-2020)
RCI-1	Demand Side Management Programs for the Residential, Commercial and Industrial Sectors	*0.3*	*0.7*		6.2
RCI-2	Expand Energy Efficiency Funds	*0.2*	*0.4*		3.6
RCI-6	Building Energy Codes	*0.0*	*0.0*		0.0
RCI-9	Green Power Purchasing (required for state facilities) and Bulk Purchasing Programs for Energy Efficiency or Other Equipment	*0.0*	*0.0*		0.3
	Total	0.5	1.2		10.1

Total Emissions Reductions Net of Overlaps (including recent actions), with RCI-1 Recommended Case	5.8	34.2		228.8

TABLE BELOW SHOWS NET ADJUSTED SAVINGS BY OPTION FOR CASE WITH RCI-1 --Recommended Case: "Top-ten States" EE Investment.

	Option Name	GHG Reductions 2010	GHG Reductions 2020	Cost-Eff ($/t$CO_2$e)	NPV 2006-2020 ($million)	Cumulative Emissions Reductions (MMt CO_2e, 2006-2020)
RCI-1	Demand Side Management Programs for the Residential, Commercial and Industrial Sectors	1.9	11.6	-$25	-$1,895	77
RCI-2	Expand Energy Efficiency Funds	1.1	5.6	-$25	-$943	38
RCI-3	Energy Efficiency Requirements for Government Buildings	0.0	0.9	-$14	-$70	5
RCI-4	Market Transformation and Technology Development Programs	0.0	1.6	-$32	-$271	8
RCI-5	Improved Appliance and Equipment Efficiency Standards	0.0	1.0	-$63	-$336	5
RCI-6	Building Energy Codes	0.5	3.5	-$17	-$400	23
RCI-7	"Beyond Code" Building Design Incentives and Targets, Incorporating Local Building Materials and Advanced Construction	0.3	2.6	-$14	-$247	17
RCI-8	Education (Consumer, Primary/Secondary, Post-Secondary/ Specialist, College and University Programs)	Not Quantified				
RCI-9	Green Power Purchasing (required for state facilities) and Bulk Purchasing Programs for Energy Efficiency or Other Equipment	0.1	0.4	$7	$24	3
RCI-10	Distributed Renewable and Clean Fossil Fuel Power Generation	1.2	4.6	$12	$392	33
RCI-11	Residential, Commercial, and Industrial Energy and Emissions Technical Assistance and Recommended Measure Implementation	0.3	1.0	-$33	-$247	7
	Total Savings	5.3	33.0	-$18	-$3,994	219

NOTES ON ESTIMATES OF OVERLAP BETWEEN POLICIES

Note 2:
The overlap between RCI-2 and RCI-1 at the at the "Recommended Case: 'Top-ten States' EE Investment" is assumed to be approximately 30%, as the sum of the two options at this RCI-1 level approach the level of "Achievable Cost-effective Energy Savings" noted above.

Note 3:
Assumes an overlap between RCI-3 and RCI-1 and -2 of 20%, which assumes relatively few government-sector improvements are subsidized by utility programs or energy efficiency funds.

Note 4:
RCI-4, Regional Market Transformation, could overlap with RCI-1 and RCI-2 if the same types of appliances, equipment, or other energy efficiency improvements, are targeted. Assuming a policy design that focuses on equipment targeted mostly at measures not covered by DSM programs, and taking into account that DSM programs will focus much more broadly than RCI-4, an overlap of no more than 20% on energy efficiency improvements through RCI-4 should be possible.

Note 5:
RCI-5 and RCI-6 have no overlap with RCI-1 through RCI-4, since savings from appliance efficiency and buildings in RCI-1 through -4 would be over and above standards and codes.

Note 6:
RCI-7 will likely have some measures that are installed using resources from RCI-1 and RCI-2. Assume an overlap of 50%

Note 7:
The Bulk Purchase component of RCI-9 will likely overlap with options RCI-1, -2, and -4. Assume an overlap of 30% in that component, but Green Power Purchasing would have no overlap with other RCI options.

Note 8:
RCI-10 would have no significant overlap with other RCI options.

Note 9:
RCI-11 would likely have substantial overlap with several other RCI options. Assume an overlap of 50%.

Estimation of Avoided Costs for North Carolina RCI GHG Analysis

Date Last Modified: 12/8/2006 D. Von Hippel/A Bailie

General approach used: Start with levelized 15-year avoided costs from Duke Power, Progress Energy, and Dominion Resource Services price schedules for qualifying facilities purchased power, as filed in late 2005 with the NCUC (Docket No. E-100, Sub 100), and create weighted average annual avoided costs by application of estimated weighting factors for on-peak and off-peak usage, and for the fraction of North Carolina's electricity supplied by each of the three utilities.

Calculation Using 15-year Levelized Rates from Duke Power (Cents/kWh), "Interconnected to Distribution Syst
Non-Hydro

(Avoided costs derived from these rates are assumed reasonable to apply to end-user energy-efficiency and small distributed generation)

	Rates		Annual Hours		Fraction of Annual Energy Applicable	
Rate Category	Option "A"	Option "B"	Option "A"	Option "B"	Option "A"	Option "B"
Capacity Credit--on-peak	2.29	8.16	5832	2928	71.0%	38.6%
Capacity Credit--off-peak	0.51	1.26	2928	5832	29.0%	61.4%
Energy Credit--on-peak	4.54	4.68	4160	1853	55%	30%
Energy Credit--off-peak	3.36	3.71	4600	6907	45%	70%

	Option "A"	Option "B"
Implied Weighted Average Total Annual Energy plus Capacity Credit	5.78	7.92

Calculation Using 15-year Levelized Rates from Progress Energy (Cents/kWh),
for Generators Not Connected to Transmission System [that is, connected to Distribution], and Non-Hydro

	Rates	Annual Hours	Fraction of Annual Energy Applicable	
Capacity Credit--on-peak	2.252	2778	40%	
Capacity Credit--off-peak	1.867	5982	60%	
Energy Credit--on-peak	4.212	2778	40%	
Energy Credit--off-peak	3.048	5982	60%	
Implied Weighted Average Total Annual Energy plus Capacity Credit				5.53

Calculation Using 15-year Levelized Rates from Dominion Resource Services (Cents/kWh)
for resources on line in 2006, and using "Option C"

	Rates	Annual Hours	Fraction of Annual Energy Applicable		
Capacity Credit (all)	0.546	8760	100%		
Energy Credit--on-peak	5.006	3911	50%		
Energy Credit--off-peak	4.123	4849	50%		
Credit for avoided line losses (applied to energy credit)				2.70%	
Implied Weighted Average Total Annual Energy plus Capacity Credit					5.25

Calculation of Weighted-average Statewide Avoided Costs

Utility		Avoided Cost Estimate From Above (cents/kWh)		Fraction of NC Sales*	Weighting Factor
Duke Power	Using Option	A	5.78	43.41%	57.6%
Progress Energy			5.53	28.69%	38.1%
Dominion Resource Services			5.25	3.28%	4.4%

* Fractions for Dominion Resources Services (as Virgina Electric & Power Company), Progress Energy and Duke Power are derived from USDOE EIA sales data for 2005 (see "Utility_Sales" worksheet in this Workbook).

Implied Utility-weighted Average Avoided Cost	**5.66**	**cents/kWh (15-year levelized)**

Estimate of Mitigation Option Costs and Benefits for North Carolina RCI GHG Analysis

RCI-1 **Demand Side Management Programs for the Residential, Commercial and Industrial Sectors**

Date Last Modified: 5/29/2007 D. Von Hippel/A Bailie

Key Data and Assumptions	2010	2020/all	Units
First Year Results Accrue		2007	
Electricity			
Current/expected utility efficiency spending			
Fraction of electric utility revenues spent on efficiency		0.04%	
Fraction of gas utility revenues spent on efficiency		0.05%	

North Carolina Utilities Commission, ANNUAL REPORT of the NORTH CAROLINA UTILITIES COMMISSION Regarding Long Range Needs for Expansion of Electric Generation Facilities for Service in North Carolina, dated 30 November 2006, page 26, quoting "ED/SELC witness Prindle", suggests that North Carolina utilities (presumably as of 2006) invested an average of 0.04 percent of utility revenue in DSM programs.
No other gas utilities have this requirement or energy efficiency programs Note that the 0.04 percent estimate does not include the impacts of recent statements by an executive of Duke power suggesting plans to increase that company's DSM investment considerably. Document available as http://www.ncuc.commerce.state.nc.us/reports/lr2006.pdf. For natural gas, a recent rate case for Piedmont gas resulted in the company agreeing to invest $1.25 million per year in energy efficiency/conservation programs over 2006-2008 (information from NCUC staff and Docket G-9, sub 499, November 3, 2005 http://ncuc.commerce.state.nc.us/cgi-bin/webview/senddoc.pgm?dispfmt=&itype=Q&authorization =&parm2=YBAAAA70350B&parm3=000123283).

No other gas utility energy efficiency investments in NC have been noted. The estimate of gas utility investment here divides the $1.25 million figure referenced above by the total estimated NC-wide gas utility revenues in 2007.

Year that action begins		2006	
Year that target is achieved		2006	
Fraction of Statewide Electricity and Gas Sales Covered			
Residential		100%	Assumption
Commercial		100%	Assumption
Industrial		100%	Assumption
Recommended Case: "Top-ten States" EE Investment			
Assuned level of spending when programs fully phased-in		$25.90	per customer-yr
By 2012, this corresponds to approximately		1.50%	of Utility Revenue

This level of spending would placed North Carolina among the top ten states in DSM spending (as of 2003) as a percentage of electricity revenues according to the list compiled (page 21) in ACEEE's 3rd National Scorecard on Utility and Public Benefits Energy Efficiency Programs: A National Review and Update of State-Level Activity, by Dan York and Marty Kushler of the American Council for an Energy-Efficient Economy. Report No. U054, Dated October, 2005.

Increase in energy efficiency spending starting in year		2007	
Ramping up to offset post-2005 growth in emissions by year		2016	

This implementation timing interprets the goals set for RCI-1 ("At a minimum, utilities must offset projected growth in emissions from the inventory base year from RCI utility gas and electricity use…") to mean that by 2016, all growth in emissions from electricity generation and gas use since 2005 should be offset, with annual incremental growth in emissions offset thereafter. The calculations that follow are used to "phase in" the required annual savings calculated as above.

For Alternative Case 1 and Recommended Case, spending assumed to ramp linearly to full levels by:		2012	

This assumption is roughly consistent with the pattern of spending growth implied for the "offset growth" case..

Annual electricity efficiency savings needed to meet reduction target, offset case	2,532	2,647	GWh
Annual gas efficiency savings needed to meet reduction target, offset case	6,181	3,015	Billion Btu

Calculated based on savings targets and phase-in schedule above. Calculation approach for estimating revenues earmarked for energy efficiency programs (below): spending levels "back-calculated" based on savings per $ spent averages presented below.

Fraction of Sales by Sector Covered			
Residential		100%	Assumption
Commercial		100%	Assumption
Industrial		100%	Assumption

Levelized Cost of Electricity Savings	**$33**	$/MWh

*Estimated based on savings included in the GDS Report for the NC Utilities Commission, A Study of the Feasibility of Energy Efficiency as an Eligible Resource as Part of a Renewable Portfolio Standard for the State of North Carolina, dated 12/2006. See **Note 2**. The 2.9 cent/kWh average from the GDS report is based on a discount rate of 10 percent nominal, and has been recalculated using a real discount rate of 5%/yr to yield the value above. See "GDS calcs" worksheet in this workbook. By comparison, a report prepared for the Western Governors Association (CDEAC EE Report, 2006--See **Note 3**), which in turn is based on Funding and Savings for Energy Efficiency Programs in Program Years 2000 through 2004 (CEC Rogers, Messenger Bender 2005) and on The Fifth Northwest Electric Power and Conservation Plan (Northwest Power and Conservation Council 2005), cites an average levelized cost of electricity savings of $25/MWh.*

Electricity Savings per Program Spending (first year savings)	**8.0**	MWh/$1000 spent, or
	$125	$/MWh 1st yr savings

Based on rough average of several sources. Since 2000, NW utilities have achieved around 7 MWh/$1000 (T. Eckman, 2006, ttp://www.nwcouncil.org/energy/present/idaho.pdf), while CA utilities have averaged closer to 5 MWh/$1000 (M. Messenger, 2003, http://www.energy.ca.gov/reports/2003-09-24_400-03-022D.PDF). A calculation of the implied cost per unit first-year savings for the energy efficiency program defined for North Carolina in the GDS report (see reference above) yield program costs (including sponsor incentive costs and administration/marketing costs) on the order of $100 per kWh.

Avoided Delivered Electricity Cost	**$57**	$/MWh

See common assumptions ("Common Factors" worksheet in this workbook)

Natural Gas Savings per Program Spending	**72,700**	MCF/yr per $million
	74,881	MMBtu/yr per $million

Based on average cost of gas DSM programs reported in Tegen, S. and Geller, H., 2006. Natural Gas Demand-Side Management Programs: A National Survey, Southwest Energy Efficiency Project, www.swenergy.org.

Levelized Cost of Natural Gas Savings	**$2.1**	$/MMBtu

Based on the first year costs above and average measure lifetime assumption below

Assumed average measure lifetime	**8**	years
Avoided Delivered Natural Gas Cost	**$8.0**	$/MMBtu

See common assumptions

Other Data, Assumptions, Calculations	2010	2020/all	Units
Calculations used to estimate target spending levels			
During 2006-2020 period, implied new annual energy savings from:			
Current/expected electric utility spending	54	64	GWh
Current/expected gas utility spending	125	142	Billion Btu
Meeting RCI-1 Recommended Case Target--Electricity	716	1,252	GWh
Meeting RCI-1 Recommended Case Target--Gas	1,785	3,015	Billion Btu
Analysis			
RCI Electricity Sales Use *(from inventory)*	134,876	159,498	GWh
Residential	56,047	68,143	GWh
Commercial	50,710	67,461	GWh
Industrial	28,119	23,895	GWh
RCI Electricity Prices (statewide averages)			
Residential	$78	$75	$/MWh
Commercial	$63	$62	$/MWh
Industrial	$48	$47	$/MWh

2005 gas prices are from EIA. http://tonto.eia.doe.gov/dnav/ng/ Changes in sectoral gas prices indexed to DOE EIA Annual Energy Outlook 2006 national forecast.

Total Electricity Revenues (RCI, statewide)	$8,934	$10,414	$million
Residential	$4,376	$5,083	$million
Commercial	$3,219	$4,208	$million
Industrial	$1,339	$1,122	$million

RCI Gas Sales *(from inventory)*	250,711	285,286	Billion Btu
Residential	78,325	95,284	Billion Btu
Commercial	50,208	56,195	Billion Btu
Industrial	122,178	133,807	Billion Btu
Conversion Factor: Million Btu per Thousand Cubic feet		1.03	MMBtu/Mcf
RCI Gas Prices (statewide averages, real 2005 dollars)			
Residential	$12.46	$12.32	$/MMBtu
Commercial	$10.15	$9.80	$/MMBtu
Industrial	$7.32	$7.13	$/MMBtu

2005 gas prices are from EIA (see "NGPrices current" worksheet in this workbook). http://tonto.eia.doe.gov/dnav/ng/xls/ng_sum_lsum_dcu_SNC_a.xls. Changes in sectoral gas prices indexed to future gas prices from DOE EIA Annual Energy Outlook 2006 national forecast.

Total Implied Gas Revenues (RCI, statewide)	$2,380	$2,679	$million
Residential	$976	$1,174	$million
Commercial	$510	$551	$million
Industrial	$894	$955	$million

Spending on Efficiency Programs

Current/expected utility efficiency spending

Efficiency Spending, Electric Utilities	$3.6	$4.2	$million
Fraction of Electricity Revenues Spent	0.04%	0.04%	
Efficiency Spending, Gas Utilities	$1.2	$1.3	$million
Fraction of Gas Revenues Spent	0.05%	0.05%	

Recommended Case: "Top-ten States" EE Investment

Efficiency Spending, Electric Utilities	$89.5	$156.5	$million
Fraction of Electricity Revenues Spent	1.00%	1.50%	
Efficiency Spending, Gas Utilities	$23.8	$40.3	$million
Fraction of Gas Revenues Spent	1.00%	1.50%	

Average Generation Level Capacity Savings per Unit Customer Energy Savings	0.219	MW/GWh

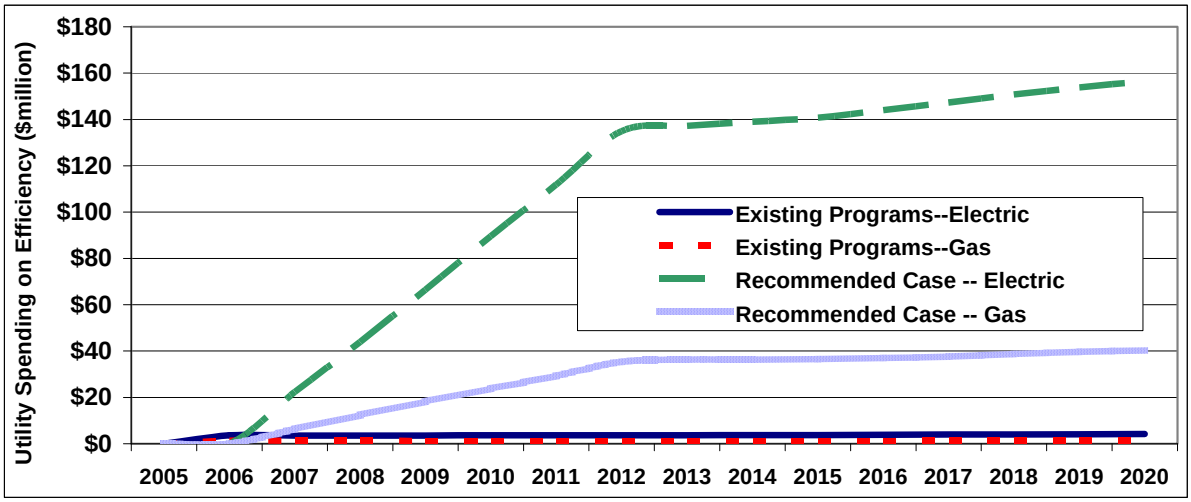
Estimated from electrical energy and peak power savings for "Achievable Cost-effective Electricity Savings Base Case for North Carolina" scenario as indicated on page 145 of A Study of the Feasibility of Energy Efficiency as an Eligible Resource as Part of a Renewable Portfolio Standard for the State of North Carolina, dated December 2006, and prepared as a Report for the North Carolina Utilities Commission by GDS Associates, Inc. Note that this "peak factor" indicates that the efficiency measures included in the indicated scenario are about twice as likely to provide savings on-peak as efficiency savings that provide the same level of energy savings at all times.

Additional Results	2010	2020	Units
Current/expected utility efficiency spending			
Reduction in Electricity Use (Cumulative)	262	854	GWh
as % of overall projected sales in that year	0.2%	0.5%	
Reduction in Generation Requirements	279	909	GWh
GHG Emission Savings	**0.2**	**0.6**	$MMtCO_2e$
Reduction in Gas Use	601	1,949	Billion Btu
as % of overall projected sales in that year	0.2%	0.7%	
GHG Emission Savings, Gas	**0.0**	**0.1**	$MMtCO_2e$

Original Case: Spending to increase energy efficiency spending sufficient to offset growth in emissions			
Reduction in Electricity Use (Cumulative)	6,153	32,803	GWh
as % of overall projected sales in that year	4.6%	20.6%	
Incremental Reduction in Generation Requirements	6,549	34,914	GWh
Incremental GHG Emission Savings, Electricity	**5.8**	**24.9**	$MMtCO_2e$
Reduction in Gas Use (Cumulative)	14,370	58,781	Billion Btu
as % of overall projected sales in that year	5.7%	20.6%	
Incremental GHG Emission Savings, Gas	**0.7**	**3.1**	$MMtCO_2e$
Alternative Case 1: Mid-Range EE Investment			
Reduction in Electricity Use (Cumulative)	591	4,361	GWh
as % of overall projected sales in that year	0.4%	2.7%	
Incremental Reduction in Generation Requirements	629	4,642	GWh
Incremental GHG Emission Savings, Electricity	**0.6**	**3.3**	$MMtCO_2e$
Reduction in Gas Use (Cumulative)	1,512	10,659	Billion Btu
as % of overall projected sales in that year	0.6%	3.7%	
Incremental GHG Emission Savings, Gas	**0.1**	**0.6**	$MMtCO_2e$
Recommended Case: "Top-ten States" EE Investment			
Reduction in Electricity Use (Cumulative)	1,777	13,109	GWh
as % of overall projected sales in that year	1.3%	8.2%	
Incremental Reduction in Generation Requirements	1,892	13,953	GWh
Incremental GHG Emission Savings, Electricity	**1.7**	**9.9**	$MMtCO_2e$
Reduction in Gas Use (Cumulative)	4,545	32,039	Billion Btu
as % of overall projected sales in that year	1.8%	11.2%	
Incremental GHG Emission Savings, Gas	**0.2**	**1.7**	$MMtCO_2e$
Implied peak power savings from			
Current/expected utility savings	57	187	MW
Spending to increase energy efficiency spending sufficient to offset growth in emissions	1,347	7,184	MW
Alternative Case 1: Mid-Range EE Investment	130	955	MW
Recommended Case: "Top-ten States" EE Investment	389	2,871	MW

Economic Analysis

Recommended Case: "Top-ten States" EE Investment			
--Electricity Programs			
Net Present Value (2007-2020)		**-$1,167**	$million
Cumulative Emissions Reductions (2007-2020)		**67**	$MMtCO_2e$
Cost-Effectiveness		**-$17**	$/tCO_2e$
--Gas Programs			
Net Present Value (2007-2020)		**-$728**	$million
Cumulative Emissions Reductions (2007-2020)		**10.4**	$MMtCO_2e$
Cost-Effectiveness		**-$70**	$/tCO_2e$
--Total of Electric and Gas Programs			
Incremental GHG Emission Savings, Electricity and Gas	**1.9**	**11.6**	$MMtCO_2e$
Net Present Value (2007-2020)		**-$1,895**	$million
Cumulative Emissions Reductions (2007-2020)		**77.1**	$MMtCO_2e$
Cost-Effectiveness		**-$25**	$/tCO_2e$



Notes and Sources

Note 1:

The "GDS Report" is available as
http://www.ncuc.commerce.state.nc.us/rps/NC RPS Energy Efficiency Report 12-06.pdf
Links to related NCUC documents on analysis of an RPS for NC (December 2006) are:
http://www.ncuc.commerce.state.nc.us/rps/NC RPS Report 12-06.pdf
http://www.ncuc.commerce.state.nc.us/rps/NC RPS Presentation to ERC 12-13-06.pdf

Note 2:

The Energy Efficiency Task Force Report to the Clean and Diversified Energy Advisory Committee of the Western Governors Association,
The Potential for More Efficient Electricity Use in the Western United States, January, 2006. This report is referred to here as the "WGA CDEAC EE report" and can be found at:
http://www.westgov.org/wga/initiatives/cdeac/Energy%20Efficiency-full.pdf.

Estimate of Mitigation Option Costs and Benefits for North Carolina RCI GHG Analysis

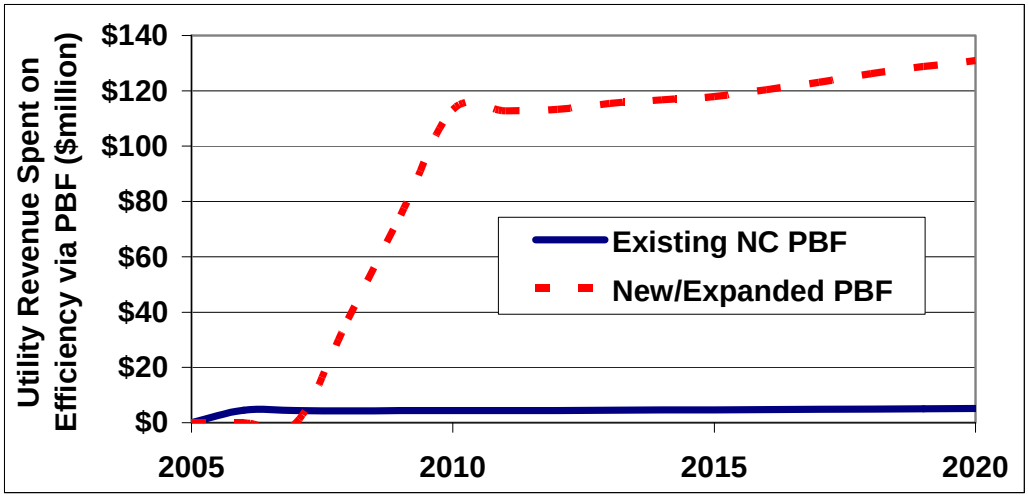
RCI-2 **Expand Energy Efficiency Funds**

Date Last Modified: 5/22/2007 D. Von Hippel/A Bailie

Key Data and Assumptions	2010	2020/all	Units
First Year Results Accrue		2007	
Electricity			
Current/expected public benefits fund (PBF) spending			
At current rate	0.003567		cents per kWh electricity sales
Implied fraction of electric utility revenues funding current PBF		0.0496%	
As included in current Public Benefits Fund charge as approved by the NCUC (see, for example source in Note 1, below). Calculation based on 2005 average electricity price from USDOE EIA statistics (see "Utility_Sales" worksheet in this workbook).			
At current rate	0		cents per MMBtu gas sales
Implied fraction of gas utility revenues funding current PBC		0.0000%	
Rows above included in case needed. North Carolina Utilities Commission staff contacted when this analysis was prepared indicated that no PBF charge for gas utilities exists in NC at present.			
Year that current/expected action begins		2006	
Year that target is achieved (fully phased-in)		2006	
Fraction of Statewide Utility Sales Covered			
Residential		100%	Assumption
Commercial		100%	Assumption
Industrial		100%	Assumption
New/Expanded Public Benefits Fund			
Target public benefits funds collection as a fraction of revenue		1.0%	
Information from a national compilation on existing and planned electric utility spending on energy efficiency programs in other states was reviewed, and indicated spending in the range from a fraction of one percent to approximately three percent of utility revenues. On that basis, one percent (1%) of utility revenues was chosen as an appropriate public benefits charge goal for North Carolina at present. Value applies to both utility electric and gas sales.			
Year that action begins		2007	
Year that target is achieved		2010	
Fraction of Sales by Sector Covered			
Residential		100%	Assumption
Commercial		100%	Assumption
Industrial		100%	Assumption
Levelized Cost of Electricity Savings		$33	$/MWh
*Estimated based on savings included in the GDS Report for the NC Utilities Commission, A Study of the Feasibility of Energy Efficiency as an Eligible Resource as Part of a Renewable Portfolio Standard for the State of North Carolina, dated 12/2006. See **Note 1**. The 2.9 cent/kWh average from the GDS report is based on a discount rate of 10 percent nominal, and has been recalculated using a real discount rate of 5%/yr to yield the value above. See "GDS calcs" worksheet in this workbook. By comparison, a report prepared for the Western Governors Association (CDEAC EE Report, 2006--See **Note 2**), which in turn is based on Funding and Savings for Energy Efficiency Programs in Program Years 2000 through 2004 (CEC Rogers, Messenger Bender 2005) and on The Fifth Northwest Electric Power and Conservation Plan (Northwest Power and Conservation Council 2005), cites an average levelized cost of electricity savings of $25/MWh.*			
Electricity Savings per Program Spending (first year savings)		8.0	MWh/$1000 spent, or
		$125	$/MWh 1st yr savings
Based on rough average of several sources. Since 2000, NW utilities have achieved around 7 MWh/$1000 (T. Eckman, 2006, ttp://www.nwcouncil.org/energy/present/idaho.pdf), while CA utilities have averaged closer to 5 MWh/$1000 (M. Messenger, 2003, http://www.energy.ca.gov/reports/2003-09-24_400-03-022D.PDF). A calculation of the implied cost per unit first-year savings for the energy efficiency program defined for North Carolina in the GDS report (see reference above) yield program costs (including sponsor incentive costs and administration/marketing costs) on the order of $100 per kWh.			
Avoided Delivered Electricity Cost		$57	$/MWh
See common assumptions ("Common Factors" worksheet in this workbook)			
Natural Gas Savings per Program Spending		72,700	MCF/yr per $million
		74,881	MMBtu/yr per $million
Based on average cost of gas DSM programs reported in Tegen, S. and Geller, H., 2006. Natural Gas Demand-Side Management Programs: A National Survey, Southwest Energy Efficiency Project, www.swenergy.org.			
Levelized Cost of Natural Gas Savings		$2.1	$/MMBtu
Based on the first year costs above and average measure lifetime assumption below			
Assumed average measure lifetime		8	years
Avoided Delivered Natural Gas Cost		$8.0	$/MMBtu
See common assumptions			

Other Data, Assumptions, Calculations	2010	2020/all	Units
Analysis			
RCI Electricity Sales *(from inventory)*	134,876	159,498	GWh
Residential	56,047	68,143	GWh
Commercial	50,710	67,461	GWh
Industrial	28,119	23,895	GWh
Conversion Factor:GWh/Billion Btu		0.29306	
RCI Electricity Prices (statewide averages, real 2005 dollars)			
Residential	$78	$75	$/MWh
Commercial	$63	$62	$/MWh
Industrial	$48	$47	$/MWh
2005 electricity prices are from EIA (see "Retail_Prices_Elec" worksheet in this workbook). http://tonto.eia.doe.gov/dnav/ng/ Changes in sectoral electricity prices indexed to DOE EIA Annual Energy Outlook 2006 national forecast.			
Total Implied Electricity Revenues (RCI, statewide)	$8,934	$10,414	$million
Residential	$4,376	$5,083	$million
Commercial	$3,219	$4,208	$million
Industrial	$1,339	$1,122	$million
RCI Gas Sales *(from inventory)*	250,711	285,286	Billion Btu
Residential	78,325	95,284	Billion Btu
Commercial	50,208	56,195	Billion Btu
Industrial	122,178	133,807	Billion Btu
Conversion Factor: Million Btu per Thousand Cubic feet		1.03	MMBtu/Mcf
RCI Gas Prices (statewide averages, real 2005 dollars)			
Residential	$12.46	$12.32	$/MMBtu
Commercial	$10.15	$9.80	$/MMBtu
Industrial	$7.32	$7.13	$/MMBtu
2005 gas prices are from EIA (see "NGPrices current" worksheet in this workbook). http://tonto.eia.doe.gov/dnav/ng/xls/ng_sum_lsum_dcu_SNC_a.xls. Changes in sectoral gas prices indexed to future gas prices from DOE EIA Annual Energy Outlook 2006 national forecast.			
Total Implied Gas Revenues (RCI, statewide)	$2,380	$2,679	$million
Residential	$976	$1,174	$million
Commercial	$510	$551	$million
Industrial	$894	$955	$million
Public Benefits Fund Spending on Efficiency			
Recent Actions			
Fraction of Electricity Revenues Spent	0.0496%	0.0496%	
Efficiency Spending for Recent Actions (Electricity)	$4.4	$5.2	$million
Cumulative reduction in sales from existing PBF spending	0.131%	0.349%	(Electric)
Fraction of Gas Revenues Spent	0.0000%	0.0000%	
Efficiency Spending for Recent Actions (Gas)	$0.0	$0.0	$million
Cumulative reduction in sales from existing PBF spending	0.000%	0.000%	(Gas)
New/Expanded Public Benefits Funds			
Fraction of Electric Revenues Spent	1.0%	1.0%	
Efficiency Spending from New/Expanded PBF (Electricity)	$89.3	$104.1	$million
Fraction of Gas Revenues Spent	1.0%	1.0%	
Efficiency Spending from New/Expanded PBF (Gas)	$23.8	$26.8	$million

Additional Results	2010	2020	Units
Current/expected public benefits fund (PBF) spending			
Reduction in Electricity Use	177	557	GWh
as % of overall projected sales in that year	0.131%	0.349%	
Reduction in Generation Requirements	188	593	GWh
GHG Emission Savings from Electricity Use Reduction	**0.2**	**0.4**	$MMtCO_2e$
Reduction in Gas Use	0	0	Billion Btu
as % of overall projected sales in that year	0.000%	0.000%	
Reduction in Gas Consumption (*same as use at present*)	0	0	Billion Btu
GHG Emission Savings from Gas Use Reduction	**0.00**	**0.00**	$MMtCO_2e$
New/Expanded Public Benefits Fund			
Reduction in Electricity Use from New/Expanded PBF	1,420	9,079	GWh
as % of overall projected sales	1.1%	5.7%	(Electric)
Incremental Reduction in Generation Requirements	1,512	9,664	GWh
GHG Emission Savings	**1.3**	**6.9**	$MMtCO_2e$
Reduction in Gas Use	3,606	22,193	Billion Btu
as % of overall projected sales in that year	1.4%	7.8%	
Reduction in Gas Consumption (*same as use at present*)	3,606	22,193	Billion Btu
GHG Emission Savings from Gas Use Reduction	**0.2**	**1.2**	$MMtCO_2e$
Economic Analysis - New/Expanded Public Benefits Funds			
Net Present Value, Electricity Savings (2007-2020)		**-$829**	$million
Cumulative Emissions Reductions, Electricity (2007-2020)		**47.4**	$MMtCO_2e$
Cost-Effectiveness, Electricity		**-$18**	$/tCO_2e$
Net Present Value, Gas Savings (2007-2020)		**-$517**	$million
Cumulative Emissions Reductions, Gas (2007-2020)		**7.4**	$MMtCO_2e$
Cost-Effectiveness, Gas		**-$70**	$/tCO_2e$
Incremental GHG Emission Savings, Electricity and Gas	**1.5**	**8.0**	$MMtCO_2e$
Net Present Value, Electricity and Gas Savings (2007-2020)		**-$1,346**	$million
Cumulative Emissions Reductions, Electricity and Gas (2007-2020)		**54.8**	$MMtCO_2e$
Cost-Effectiveness, Electricity and Gas		**-$25**	$/tCO_2e$



NOTES AND DATA FROM SOURCES

Note 1:

Description of State Actions Policies: North Carolina, from USEPA Action Plans Database
http://yosemite.epa.gov/gw/StatePolicyActions.nsf/uniqueKeyLookup/MSTY5NM5VW?OpenDocument

Note 2:

The "GDS Report" is available as
http://www.ncuc.commerce.state.nc.us/rps/NC RPS Energy Efficiency Report 12-06.pdf
Links to related NCUC documents on analysis of an RPS for NC (December 2006) are:
http://www.ncuc.commerce.state.nc.us/rps/NC RPS Report 12-06.pdf
http://www.ncuc.commerce.state.nc.us/rps/NC RPS Presentation to ERC 12-13-06.pdf

Note 3:

The Energy Efficiency Task Force Report to the Clean and Diversified Energy Advisory Committee of the Western Governors Association,
The Potential for More Efficient Electricity Use in the Western United States, January, 2006. This report is referred to here as the "WGA CDEAC EE report" and can be found at:
http://www.westgov.org/wga/initiatives/cdeac/Energy%20Efficiency-full.pdf.

Estimate of Mitigation Option Costs and Benefits for North Carolina RCI GHG Analysis

RCI-3 **Energy Efficiency Requirements for Government Buildings**

Date Last Modified: *6/1/2007 D. Von Hippel/A Bailie*

Key Data and Assumptions	2010	2020/all	Units
First Year Results Accrue		2011	

Based on goal set in Mitigation Option Design for RCI-3 (version dated 10/27/06) that reads "Commence with all buildings entering the design phase by 2010. Based on a state composite average, achieve a 20% reduction from a baseline fiscal year of 2002-03 in energy consumption per gross square foot per year for the entire North Carolina government existing building stock by 2027".

Electricity	2010	2020/all	Units
Levelized Cost of Electricity Savings		$35	$/MWh

Based on estimate in WGA CDEAC EE Report. (See Note 1, below.) Although this estimate is based on building efficiency improvements driven by code changes, it is on the order of estimates for the costs of efficiency improvements for "beyond code" changes included in a recent report by the Southwest Energy Efficiency Project (SWEEP--see Note 2). Value here adjusted for NC prices based on 7-year payback estimated in WGA CDEAC EE Report. (See Note 1 in RCI-6.)

Levelized Cost of Natural Gas Savings		$5.1	$/MMBtu

As estimated for RCI-6. Based on 7-year payback as estimated in WGA CDEAC EE Report. (See Note 1 in RCI-6.)

Avoided Electricity Cost		$57	$/MWh

See "AvCost" and "Common Factors" worksheets in this workbook.

Avoided Natural Gas Cost		$8.0	$/MMBtu

See "NG prices aeo2006" and "Common Factors" worksheets in this workbook.

Other Data, Assumptions, Calculations	2010	2020/all	Units
Inputs to/Intermediate Results of Calculation of Electricity and Gas Savings			
Average Electricity and Gas Savings Beyond Code Levels (new government buildings)	0%	16%	

The description for this option currently includes a goal of 20 percent improvement in the entire NC building stock by 2027, and specifies that "New construction and major renovations of government buildings must meet LEED+ requirements." The values shown above for these parameters are initial assumptions.

Note in particular that the level of savings shown here is beyond that already included in Option RCI-6, and thus already includes an improvement in efficiency relative to average current practice.

Total Commercial Floorspace in North Carolina (million square feet)	2,427	2,780	

Estimated (see "NC_Activities_Est" worksheet in this workbook) based on USDOE EIA CBECS (comercial survey) data for the South Atlantic region, extrapolated using projected North Carolina population as a driver.

Est. area of new commercial space per year (million square feet)	35.7	36.6	

Calculated based on estimates above.

Implied Average Electricity Consumption per Square Foot Commercial Space in North Carolina as of 2005 (see ***Note 3***)		19.59	kWh/yr
Implied Average Natural Gas Consumption per Square Foot Commercial Space in North Carolina as of 2005 (see ***Note 3***)		19.09	kBtu/yr
Electricity Use per New/Renovated Commercial Sq. Ft. After RCI-6 Application	16.3	16.3	kWh/yr

Based on application of RCI-6 (20% efficiency improvement)--see calculations and notes in "RCI-6" worksheet in this workbook. with ultimate savings of 20 percent relative to current building codes

Nat. Gas Use per New/Renovated Commercial Sq. Ft. After RCI-6 Application	15.6	15.6	kBtu/yr

Assumes the same pattern of code improvement as for electricity use, as described above.

Implied Electricity Use per New/Renovated Commercial Square Foot After RCI-6 Application, Relative to Average in North Carolina as of 2005	83.0%	83.0%	
Implied Natural Gas Use per New/Renovated Commercial Square Foot After RCI-6 Application, Relative to Average in North Carolina as of 2005	83.0%	83.0%	
Required Net Elect/Gas Use per Square Foot New Government Space After RCI-3 Policy Relative to Average in North Carolina in 2005	First Year	75%	
	In 2020	67%	

Placeholder estimate, to be revised in consultation with TWG (based on pattern of improvement implied by meeting LEED energy specifications, as noted in RCI-3 Option Design).

Required Net Elect/Gas savings per Square Foot Existing Government Space After RCI-3 Policy Relative to Average in North Carolina in 2005	**0.0%**	**11.8%**	

Based on "20 percent improvement by 2027" as noted in RCI-3 Option Design.

Government floorspace (including leased) by year (million square feet)	**476**	**546**	
Implied total electricity savings in existing buildings from RCI-3	**-**	**1,236**	GWh/yr
Implied total gas savings in existing buildings from RCI-3	**-**	**1,205**	GBtu/yr

Average Fraction of Improvement in Electric Energy Intensities from:

Energy Efficiency Improvement	93%	90%
Solar Thermal Energy (hot water/space heat/space cooling)	5%	7%
On-site Solar PV	1%	2%
On-site Biomass/Biogas/Landfill Gas Energy Use	1%	1%
Green Power Purchase (from off-site, beyond electricity supply RPS)	0%	0%

All "placeholder" assumptions, except on-site biomass/biogas/landfill gas energy use calculated so that values sum to 100%.

Average Fraction of Improvement in Gas Energy Intensities from:

Energy Efficiency Improvement	95%	93%
Solar Thermal Energy (hot water/space heat/space cooling)	5%	7%
On-site Solar PV	0%	0%
On-site Biomass/Biogas/Landfill Gas Energy Use	0%	0%
Green Power Purchase (from off-site, beyond electricity supply RPS)	0%	0%

All "placeholder" assumptions, except on-site biomass/biogas/landfill gas energy use calculated so that values sum to 100%.

Adjustment for Inclusion of Rennovated Commercial Space as Well as New Under New Code Requirements. **1.30**

Currently set at 1.3 so that about 0.3 unit of renovated space is included per unit of new space (initial assumption). Based on regional and national studies--see ***Note 4****. It may be useful to obtain further NC-specfic information regarding this value if available in the future.*

Adjustment of Energy Use per Unit Floor Area for State/State-funded Buildings Relative to Average Commercial Building in North Carolina	1.00	1.00

Placeholder assumption.

Adjustment to Include Floor Area of New/Renovated space occupied by state and local government agencies in leased buildings.	1.10	1.10

Placeholder assumption. Data available from the North Carolina State Property Office (http://www.ncspo.com/fis/) suggests that there are well over 100 state-leased buildings (and spaces in buildings), but in many cases information on the floorspace of those leases is not available. Likewise, data on the fraction of municipal and county government-leased floorspace was not readily available, thus 10 percent is used as an overall figure-of-merit until better data are available.

Fraction of New/Renovated Commercial Space in Government Buildings 17.8%

*This estimate includes state-owned buildings plus local government buildings, including schools. Estimate starts with a compilation of the floorspace of state-owned buildings in North Carolina, and applies the ratio of state-owned buildings to total non-federal government-owned commercial-sector floorspace in the South Atlantic region, as described in CBECS 2003 data (see "NC_Activities_Est" worksheet in this workbook), pending receipt of NC-specific data for non-state government-owned building area (****see Note 5****). This estimate assumes that the ratio of floorspace in new government buildings to floorspace in all new commercial buildings is similar to the ratio of floorspace in existing government buildings to floorspace in all existing commercial buildings.*

Adjustment to Exclude Floor Area of New/Renovated State/State-funded buildings not included in option.	1.00	1.00

Placeholder assumption. Reduce below 1.0 if, for example, the option is designed to exclude small or special-use buildings.

Implied Annual Square Feet New Building Space Covered by Policy (million)	**-**	**9.34**	

Implied Cumulative Impacts of Option, New Government Space (Electricity savings)

Energy Efficiency Improvement	**-**	**170.00**	GWh
Solar Thermal Energy (hot water/space heat/space cooling)	**-**	**11.61**	GWh
On-site Solar PV	**-**	**3.01**	GWh
On-site Biomass/Biogas/Landfill Gas Energy Use	**-**	**1.86**	GWh
Green Power Purchase (from off-site, beyond electricity supply RPS)	**-**	**-**	GWh

Implied Cumulative Impacts of Option, New Government Space (Natural Gas savings)			
Energy Efficiency Improvement	-	**167.29**	GBtu/yr
Solar Thermal Energy (hot water/space heat/space cooling)	-	**11.11**	GBtu/yr
On-site Solar PV	-	-	GBtu/yr
On-site Biomass/Biogas/Landfill Gas Energy Use	-	**(0.00)**	GBtu/yr
Green Power Purchase (from off-site, beyond electricity supply RPS)	-	-	GBtu/yr
Implied Cumulative Impacts of Option, Existing Government Space (Electricity savings)			
Energy Efficiency Improvement	-	**1,112.60**	GWh
Solar Thermal Energy (hot water/space heat/space cooling)	-	**86.54**	GWh
On-site Solar PV	-	**24.72**	GWh
On-site Biomass/Biogas/Landfill Gas Energy Use	-	**12.36**	GWh
Green Power Purchase (from off-site, beyond electricity supply RPS)	-	-	GWh
Implied Cumulative Impacts of Option, Existing Government Space (Natural Gas savings)			
Energy Efficiency Improvement	-	**1,120.21**	GBtu/yr
Solar Thermal Energy (hot water/space heat/space cooling)	-	**84.32**	GBtu/yr
On-site Solar PV	-	-	GBtu/yr
On-site Biomass/Biogas/Landfill Gas Energy Use	-	**(0.00)**	GBtu/yr
Green Power Purchase (from off-site, beyond electricity supply RPS)	-	-	GBtu/yr

Additional Inputs to/Intermediate Results of Costs

Estimated annual levelized cost of solar hot water per unit output	**20.77**	**18.70**	$/MMBtu

Based on inputs to/results of solar hot water heating analysis included in other RCI options.

Adjustment to solar thermal costs for inclusion of space heat/cooling measures	1.00	1.00	

Placeholder assumption--Value of 1.0 implies that solar space heat and cooling will cost the same per unit output as solar water heating.

Implied Per Unit Cost Electricity Avoided by Solar WH/SH/Cooling	**65.91**	**59.32**	$/MWh
Implied Per Unit Cost Natural Gas Avoided by Solar WH/SH/Cooling	**14.54**	**13.09**	$/MMBtu

Assumes delivered solar WH/SH/Cooling replaces electric with EF of 0.93, gas with EF of 0.70 (and therefore one MMBtu of delivered solar heat is the equivalent of more than one MMBtu of each fuel).

Estimated annual levelized cost of on-site Solar PV	**223**	**129**	$/MWh

Based on inputs to/results of solar PV analysis included in RCI-10.

Fuel Cost for On-site Biomass/Biogas/Landfill Gas Energy Use		2.38	$/MMBtu

Based on costs for Biomass fuel, which will likely dominate this category of fuel inputs. See "Common Assumptions" worksheet in this workbook. If significantly processed biomass fuels (such as pelletized fuels) are required, this cost may need to be increased.

Relative Efficiency of On-site Biomass/Biogas/Landfill Gas displacing electricity		0.75	

Placeholder assumption.

Factor to reflect probable higher costs of on-site Biomass/Biogas/Landfill Gas Equipment Relative to Electric Equipment		2.00	

Placeholder assumption--In most cases, heating/water heating equipment designed to use biomass-derived fuels will be more expensive than equipment designed to use electricity. This factor loads these incremental capital costs into estimated fuel costs.

Implied Per Unit Cost Electricity Avoided by Biomass/Biogas/Landfill Gas	**21.59**	**21.59**	$/MWh
Incremental Cost for Green Power Purchase (from off-site, beyond supply RPS)	25.00	16.71	$/MWh

Linked to RCI-9.

Implied use of biomass/biogas/landfill gas by year	-	**64.49**	Billion Btu

Results	2010	2020	Units
Electricity (Conventional)			
Reduction in Electricity Sales: Residential (not included here)	0	0	GWh (sales)
Reduction in Electricity Sales: Commercial (government)	0	1,423	GWh (sales)
TOTAL Reduction in Electricity Sales	0	1,423	GWh (sales)
Reduction in Generation Requirements	0	1,507	GWh (generation)
GHG Emission Savings	**0.00**	**1.07**	$MMtCO_2e$
Economic Analysis			
Net Present Value (2007-2020)		**-$77**	$million
Cumulative Emissions Reductions (2007-2020)		6.0	$MMtCO_2e$
Cost-Effectiveness		**-$12.89**	$/tCO_2e$
Natural Gas			
Reduction in Gas Use	0	1,383	Billion BTU
GHG Emission Savings	**0.00**	**0.07**	$MMtCO_2e$
Economic Analysis			
Net Present Value (2007-2020)		**-$10**	$million
Cumulative Emissions Reductions (2007-2020)		0.4	$MMtCO_2e$
Cost-Effectiveness		**-$27.18**	$/tCO_2e$
Biomass/Biogas/Landfill Gas Fuel Use			
Added GHG Emissions from Biomass Fuels Use	**0.00000**	**0.00018**	$MMtCO_2e$
Cumulative added Emissions from Biomass Fuels (2007-2020)		0.0009	$MMtCO_2e$

Summary Results for RCI-3	2010	2020	Units
Total for Policy (Natural gas and electricity less biomass)			
GHG Emission Savings	**0.00**	**1.15**	$MMtCO_2e$
Net Present Value (2007-2020)		**-$87.7**	$million
Cumulative Emissions Reductions (2007-2020)		6.4	$MMtCO_2e$
Cost-Effectiveness		**-$13.74**	$/tCO_2e$

NOTES AND DATA FROM SOURCES

Note 1:

From The Energy Efficiency Task Force Report to the Clean and Diversified Energy Advisory Committee of the Western Governors Association.
The Potential for More Efficient Electricity Use in the Western United States, January, 2006. This report is referred to here as the "WGA CDEAC EE report" and can be found at:
http://www.westgov.org/wga/initiatives/cdeac/Energy%20Efficiency-full.pdf.

In the WGA CDEAC EE report, Building Code improvements were effectively modeled in two steps. The first, assumed to be effectively a baseline action, in the context of this study, but called the "Current Activities" case, brought codes up to recent IIEC levels as follows:

> "In particular, we assume adoption of a recent version of the IECC leads to 5% electricity savings on average in states in colder or moderate climates, and 13% savings in homes in very hot climates (AZ, TX, and NV). Regarding commercial buildings, we assume adoption of the code leads to 10% electricity savings in moderate and colder states, and 15% savings in very hot states (Kinney, Geller, and Ruzzin 2003). For California, we used estimates of the electricity savings from building code upgrades adopted in 2001 and 2005 (Mahone, et al. 2005). These savings levels are prior to the adjustment for savings realization mentioned in Table V.1" [Quote from footnote, page 40]

The second increase, to the CDEAC "Best Practices" Scenario, included the following improvements:

> "This [Best Practices] scenario assumes that the International Energy Conservation Code, 2004 version, is adopted in 2007 in all states except California, as California has its own more stringent standard. It is assumed that state and/or local building energy codes are upgraded in 2011 (3% improvement) and in 2015 (additional 6% improvement). This scenario also assumes that compliance and enforcement are improved and that a 90% savings realization rate is achieved. Finally, we assume that California's current building energy codes will be upgraded in 2009 (3%), 2013 (6%) and 2017 (3%)." [Quote from page 41]

The CDEAC report provides a cost of saved energy (electricity) of 4.74 cents/kWh, in 2005 dollars, based on an average 7-year payback for code improvements (page 42).

Note 2:

The Southwest Energy Efficiency Project's (SWEEP) Report
Increasing Energy Efficiency in New Buildings in the Southwest: Energy Codes and Best Practices
includes state-by-state estimates of the potential savings from two scenarios of building code and "beyond code" efficiency improvements.

For New Mexico, as an example, the cost and energy savings figures shown in the SWEEP report suggest the following for the "Strong Improvement" scenario:

	2010	2020	
Costs (million)	35.1	44	Constant 2003 dollars
TBtu Saved	3.1	7.5	Electric plus Gas
Implied $/MMBtu	11.32	5.87	
Implied $/MWh	38.63	20.02	

Note 3:
Based on results from Table B.5 of the 2003 Commercial Buildings Energy Consumption Survey, Detailed Tables dated October 2006 and published by the US Department of Energy's Energy Information Administration, and available as http://www.eia.doe.gov/emeu/cbecs/cbecs2003/detailed_tables_2003/pdf2003/alltables.pdf, as described in "NC_Activities_Est" worksheet in this workbook.

Following data on electricity sales in North Carolina as of 2005 as described in "Utility_Sales" worksheet in this workbook. Downloaded from http://www.eia.doe.gov/cneaf/electricity/epa/epa_sprdshts.html (file sales_revenue.xls)

	MWh	Fraction of Total
Residential	54,072,734	42%
Commercial	44,161,328	34%
Industrial	30,101,279	23%
Total	128,335,341	100%

For natural gas consumpation, consumption data from the USDOE EIA downloaded from http://www.eia.doe.gov/oil_gas/natural_gas/applications/eia176query.html are are follows:
(See "EIA_NG_Data" worksheet in this workbook for raw EIA data)

	Sales (Million Cubic Feet of Natural Gas)			
	Residential	Commercial	Industrial	Total
2005	63,865	41,776	22,956	128,597
Fraction of 2005 Total	50%	32%	18%	100%

Note 4:
The estimate of 0.3 unit of renovated space per unit of new construction in the commercial sector is a rough assumption.
It is likely that the ratio of commercial space undergoing major renovation to new commerial space will fluctuate year by year. A review of CBECS data (Table B5, see reference in Note 2 for RCI-7) suggests that in the South Atlantic Region renovated space (space renovated since 1980) is about one-third of new commercial building space constructed since 1980.
Some of these renovations likely would not affect building energy performance, but CBECS data suggest that a substantial portion of renovated space involves changes to outside walls and roofs, additions or annexes, or changes to HVAC systems, all of which would seem to be markets for RCI-3.
It is clear that the renovation market represents a substantial opportunity for improving energy efficiency through the type of "beyond code" changes included in this option.
Looking at the few easily accessible studies nationwide, a study of the non-residential renovation market in California (Remodeling and Renovation of Nonresidential Buildings in California, by Donald R. Dohrmann, John H. Reed, Sylvia Bender, Catherine Chappell, and Pierre Landry, available as http://www.energy.ca.gov/papers/2002-08-18_aceee_presentations/PANEL-10_DOHRMANN.PDF) suggests that by 1999 the value of renovations and additions to non-residential space was similar to that in new non-residential space, based on building permit data. As both California and North Carolina include a significant fraction of older buildings in their building stocks, the analogy with California may be reasonable for North Carolina. A study for a Texas building code report, however (see http://www.pnl.gov/main/publications/external/technical_reports/PNNL-15356.pdf) referenced the California report, but concluded that a more appropriate "conservative" value was approximately 20 percent as a long-term national average.

Note 5:
The following data were provided by Leonard Hoey of the NC State Energy Office, and reflect "gross square feet" of building area "as reported by the State Property Office". North Carolina-specific data on building area of non-State government buildings (including public schools and local/county government agencies, for example) are not yet available.

Date	Gross Square Feet
2002	93,988,942
2003	95,414,322
2004	96,159,042
2005	100,646,539
2006	105,668,142

The 2006 figure shown above for State buildings, however, can be used along with regional data from CBECS for the South Atlantic region (see "NC_Activities_Est" worksheet in this workbook) to estimate total government building area (state and non-state) as follows:
Fraction of total non-federal government buildings in the South Atlantic region that are state buildings (from CBECS, as of 2003): 25.9%
Implied year 2006 total area of non-federal government buildings in NC (million square feet): 408

Estimate of Mitigation Option Costs and Benefits for North Carolina RCI GHG Analysis

RCI-4 **Market Transformation and Technology Development Programs**

Date Last Modified: 2/12/2007 D. Von Hippel/A Bailie

Key Data and Assumptions	2010	2020/all	Units
First Year Results Accrue		**2012**	
Savings from Alliance Programs			
Reduction in overall electricity use		**0.2%**	per year

Based on WGA (2005) - The Potential for More Efficient Electricity Use in the Western United States, Energy Efficiency Task Force Report to the Clean and Diversified Energy Advisory Committee of the Western Governors' Association. This study estimates that market transformation programs could achieve reductions in electricity consumption of about 0.2% per year, based on programs and experience similar to those of the Northwest Energy Efficiency Alliance. See NEEA 2004 Annual Report. www.nwalliance.org/resources/documents/A_2004AR.pdf. These savings are in addition to those achieved through building energy codes and utility DSM programs (no double counting).

For North Carolina, a key implementation strategy could be support for and expansion of the Southeast Energy Efficiency Alliance, www.seea.us, which was initiated in 2006 as a subsidiary to the Alliance to Save Energy.

Assumed Cost of Market Transformation Program Savings		**$12**	$/MWh

From WGA EE Task Force study (2005), which cites the Retrospective Analysis of the Northwest Energy Efficiency Alliance (Violette, Ozog, and Cooney, 2003).

Avoided Electricity Cost		**$57**	$/MWh

See common assumptions.

Other Data, Assumptions, Calculations	2010	2020/all	Units
Total Statewide Electricity Sales	**134,876**	**159,498**	**GWh**

Results	2010	2020	Units
Total Net GHG Emission Savings	**0.0**	**2.0**	$MMtCO_2e$
Net Present Value (2007-2020)		**-$339**	$million
Cumulative Emissions Reductions (2007-2020)		10.5	$MMtCO_2e$
Cost-Effectiveness		**-$32**	$\$/tCO_2e$
TOTAL Reduction in Electricity Sales	0	2,687	GWh (sales)
as share of projected sales	0.0%	1.7%	
Reduction in Generation Requirements	0	2,846	GWh (generation)

Estimate of Mitigation Option Costs and Benefits for North Carolina RCI GHG Analysis

RCI-5 **Improved Appliance and Equipment Efficiency Standards**

Date Last Modified: 2/12/2007 D. Von Hippel/A Bailie

Key Data and Assumptions	2010	2020/all	Units
First Year Results Accrue		**2012**	
Projected Electricity Savings from 15 Proposed Standards (in 2020)		**1,297**	GWh
Projected Natural Gas Savings from 15 Proposed Standards (in 2020)		**363**	million ft^3
Projected NPV Savings (to 2030, $2005)		**$943**	million

The above findings are drawn from ASAP and ACEEE, 2006. "Leading the Way: Continued Opportunities for New State Appliance and Equipment Efficiency Standards", http://www.standardsasap.org/stateops.htm. The NPV results were derived using a 5% discount rate, and electricity prices of 8.7c/kWh ($13.6/thousand cubic ft gas) residential and 6.9c/kWh ($11.7/thousand cubic ft gas) commercial. The resulting NPV savings are thus slightly higher than would be obtained using our avoided delivered electricity and gas cost estimates.

Adjustment factor for NPV timespan **0.527**

This is the ratio of NPV values from 2007-2020 vs. 2005-2030 for a constant net benefit starting in 2012.

Adjustment factor for different electricity and gas avoided costs **0.677**

Simple adjustment assumes the benefits are largely on the electricity side, and equals the ratio of incremental cost savings per MWh using the following values (appliance standards cost from WGA 2005; ASAP/ACEEE assumes average of res and comm):

Average cost of efficiency improvements via standards		**$12**	$/MWh
Average cost of electricity in ASAP/ACEEE study		**$78**	$/MWh
Avoided cost used here (res/comm avg)		**$57**	$/MWh

Other Data, Assumptions, Calculations	2010	2020/all	Units
National Savings	14	52	TWh

ASAP/ACEEE, 2006. Assume here same ratio of 2010 to 2020 savings in NC for electricity. All gas-saving standards come into force in 2012, so no 2010 gas savings

Results	2010	2020	Units
Electricity			
Reduction in Electricity Sales	0	1,297	GWh (sales
Reduction in Generation Requirements	0	1,374	GWh (gene
GHG Emission Savings	**0.00**	**0.98**	$MMtCO_2e$
Cumulative Emissions Reductions (2007-2020)		5.2	$MMtCO_2e$
Natural Gas			
Reduction in Gas Use	0	374	Billion BTU
GHG Emission Savings	**0.00**	**0.02**	$MMtCO_2e$
Cumulative Emissions Reductions (2007-2020)		0.10	$MMtCO_2e$
Total for Option (Natural gas and electricity)			
GHG Emission Savings	**0.00**	**1.00**	$MMtCO_2e$
Net Present Value (2007-2020)		**-$336**	$million
Cumulative Emissions Reductions (2007-2020)		5.3	$MMtCO_2e$
Cost-Effectiveness		**-$63**	$/$tCO_2e$

Estimate of Mitigation Option Costs and Benefits for North Carolina RCI GHG Analysis

RCI-6 **Building Energy Codes**

Date Last Modified: 5/31/2007 D. Von Hippel/A Bailie

Key Data and Assumptions	2010	2020/all	Units
First Year Results Accrue		**2008**	
Electricity	**2010**	**2020/all**	**Units**
Levelized Cost of Electricity Savings		**$35.0**	$/MWh
Based on 7 year payback as estimated in WGA CDEAC EE Report. (See Note 1, below.)			
Levelized Cost of Natural Gas Savings		**$5.1**	$/MMBtu
Based on 7 year payback as estimated in WGA CDEAC EE Report. (See Note 1, below.)			
Avoided Electricity Cost		**$57**	$/MWh
Weighted average over total 2007-2020 electricity savings for this policy in each sector. See common assumptions ("Common Factors" worksheet in this workbook).			
Avoided Natural Gas Cost		**$8**	$/MMBtu
See common assumptions ("Common Factors" worksheet in this workbook)			

Other Data, Assumptions, Calculations	2010	2020/all	Units
Adjustment for Inclusion of Rennovated Residential Space as Well as New Under New Code Requirements.		**1.00**	
(Currently set at 1.0 so that no rennovated residential space is included--need to ask an NC building professional for an opinion on this value.)			
Adjustment for Inclusion of Rennovated Commercial Space as Well as New Under New Code Requirements.		**1.30**	
Currently set at 1.3 so that about 0.3 unit of renovated space is included per unit of new space (initial assumption). Based on regional and national studies--see Note 3. It may be useful to obtain further NC-specfic information regarding this value if available in the future.			
Adjustment for Inclusion of New Industrial Space in Estimated Savings due to New Code Requirements (applied to total residential plus commercial savings) (See ***Note 3***)		**104.4%**	
Ratio of Electricity Savings to Gas Savings: Residential Sector	730	730	GWh/TBtu
Ratio of Electricity Savings to Gas Savings: Commercial Sector	943	943	GWh/TBtu
Estimated based on relative NC usage of electricity and gas by sector in 2004. Alternative factors could be derived from other sources to account for differences in expected levels of electricity and natural gas savings.			

Results	2010	2020	Units
Electricity			
Recent Actions not included in forecast -- assume all recent savings are included in forecast			
Reduction in Electricity Sales: Residential	0	0	GWh (sales)
Red		0	GWh (sales)
Red		0	GWh (sales)
TOT		0	GWh (sales)
Reduction in Generation Requirements	0	0	GWh (generati
GHG Emission Savings	**0.00**	**0.00**	$MMtCO_2e$
Savings due to Additional Effort in RCI-6			
Reduction in Electricity Sales: Residential	254	2,395	GWh (sales)
Reduction in Electricity Sales: Commercial	199	1,731	GWh (sales)
Reduction in Electricity Sales: Industrial	20	182	GWh (sales)
TOTAL Reduction in Electricity Sales	473	4,307	GWh (sales)
Reduction in Generation Requirements	504	4,563	GWh (generati
GHG Emission Savings	**0.44**	**3.25**	$MMtCO_2e$
Economic Analysis (for Electricity Savings due to Additional Effort in RCI-6)			
Net Present Value (2007-2020)		**-$342.6**	$million
Cumulative Emissions Reductions (2007-2020)		21.4	$MMtCO_2e$
Cost-Effectiveness		**-$16.00**	$/tCO_2e$

These rows are not used currently but are retained in case there is need to estimate savings from current activities

Natural Gas

Recent Actions not included in forecast

These rows are not used currently but are retained in case there is need to estimate savings from current activities

Reduction in Gas Sales: Residential	0	0	Billion BTU
Reducti		0	Billion BTU
Reducti		0	Billion BTU
Reducti		0	Billion BTU
GHG Emission Savings	0	0.00	$MMtCO_2e$

Savings due to Additional Effort in RCI-6

Reduction in Gas Sales: Residential	348	3,280	Billion BTU
Reduction in Gas Sales: Commercial	211	1,836	Billion BTU
Reduction in Gas Sales: Industrial	21	193	Billion BTU
Reduction in Gas Use	581	5,309	Billion BTU
GHG Emission Savings	0.03	0.28	$MMtCO_2e$

Economic Analysis (for Savings due to Additional Effort in RCI-6)

Net Present Value (2007-2020)	**-$57.9**	$million
Cumulative Emissions Reductions (2007-2020)	1.7	$MMtCO_2e$
Cost-Effectiveness	**-$34.40**	$/tCO_2e$

Summary Results for RCI-6	2010	2020	Units
Recent Actions Not Included in Forecast (Current/planned building code changes)			
Electric GHG Emission Savings	**0.00**	**0.00**	$MMtCO_2e$
Gas GHG Emission Savings	**0.00**	**0.00**	$MMtCO_2e$
Total GHG Emission Savings	**0.00**	**0.00**	$MMtCO_2e$
Total for Option (Natural gas and electricity)			
GHG Emission Savings	**0.47**	**3.53**	$MMtCO_2e$
Net Present Value (2007-2020)		**-$400**	$million
Cumulative Emissions Reductions (2007-2020)		23.1	$MMtCO_2e$
Cost-Effectiveness		**-$17.34**	$/tCO_2e$

NOTES AND DATA FROM SOURCES

Note on Overall Approach to Analysis

The analysis for this option is based on structure used by the Building Codes Assistance Project (see http://www.bcap-energy.org). The analysis uses existing energy consumption and parameters to account for savings due to energy used for space conditioning in different climates and the estimated impact of building codes.

From Mitigation Option Description, the goals of the option are

- **Goals:**
  - Enforce existing building energy codes by 2008.
  - Establish a new energy code by 2010 that requires new NC residences and commercial/industrial buildings to be 20% more efficient than buildings meeting current national building energy codes, and assure that the new code is enforced.

This analysis estimates the savings from full enforcement of the existing NC building code (according to energycodes.gov, "The NC Building Code Council has adopted the 2003 IECC with NC amendments effective July 1, 2006. The amendments include adoption of ASHRAE 90.1-2004. Chapter 11 of the 2003 IRC has also been adopted and includes NC amendments; the effective date for the new 2006 NC Residential Code has been delayed until July 1, 2007."
IECC is the International Energy Conservation Code

For 2008, this analysis assumes that the 2006 code (based on IECC 2003) achieves energy savings of

residential	3%	, eg standard practice is equivalent to about 1998 IECC levels
commercial	6%	, eg standard practice is equivalent to about ASHRAE 2001 levels

This assumption is based on notes provided by the Building Codes Assistance Project
(see notes on cells in column T and V in table below)

For enforcement rates, the analysis assumes:

	rate of energy code enforcement currently, before mitigation action (no source for this
50%	estimate, needs review by TWG)
95%	rate of energy code enforcement with this mitigation option in place

These are rough estimates and more appropriate values for North Carolina are welcomed.

For 2010, this analysis assumes that the current national building code will be approximately IECC 2003, or the equivalent of NC's 2006 code. Thus the options will achieve

20%	savings, relative to 2008 improvements

Annual energy savings are estimated using the table below are result in estimated savings of

2008 (code enforcement)

residential	0.019	TWh
Commercial	0.017	TWh

2010 (20% energy savings)

residential	0.206	TWh
Commercial	0.113	TWh

The above values are based on energy and households in 2005, these values are adjusted to provide future savings based on increased number of houses. See below

	RESIDENTIAL							
STATE	TOTAL HOUSING UNITS	NEW HOUSING UNITS AUTHORIZED BY PERMIT (PRIVATELY OWNED)		Ratio - new units / existing units	TOTAL ELECTRICITY ENERGY USE (TWh) 2005	Estimated Electric energy use, new residential units (TWh)	Electric space conditioning multiplier (see "HVAC and Fuel Mix" worksheet)	energy use for space conditioning - new res buildings (TWh)
full enforcement of 2006 IECC								
NC	4,022,589	82035		0.0204	54.1	1.10	26.0%	0.2870
20% improvement								
NC						1.0841		

Incremental annual energy savings		2007	2008	2009	2010	2011	2012	2013
Residential	TWh	0	0.019	0.019	0.216	0.206	0.209	0.212
Commercial	TWh	0	0.017	0.017	0.119	0.113	0.115	0.117
growth factor, population based relative to population growth from 2005 (energy savings based on 2005 data)			1.02	1.03	1.05	1.00	1.01	1.03

North Carolina	New housing units	82,035	2005

COMMERCIAL						ENERGY SAVINGS POTENTIAL (TWh)						Code in 2006	
Ratio - new/existing	TOTAL ELECTRICITY ENERGY USE (TWh) 2005	Energy Intensity Correction Factor by Climate Zone and Vintage	Percentage of electric energy for Heating, Cooling, and Lighting	Commercial electric energy use for Heating, Cooling, & Lighting for new buildings (TWh)	STATE	Residential Savings Multiplier reflecting change from 2006 state code to 2004/2006 IECC.	Energy Savings Potential Residential New Construction	Energy Savings Potential Replacement Window	Commercial Savings Multiplier reflecting change from 2006 state code to ASHRAE 90.1-2004.	Energy Savings Potential Commercial New Construction	STATE	Residential	Commercial
0.0216	44.2	1.20	0.54	0.61	NC	0.030	0.015	0.004	0.060	0.017	NC	2003 IECC	2003 IECC
				0.60	NC	0.200	0.206	N/A	0.200	0.113	NC	2003 IECC	2003 IECC

2014	2015	2016	2017	2018	2019	2020
0.215	0.218	0.210	0.213	0.216	0.219	0.222
0.118	0.120	0.116	0.117	0.119	0.121	0.122
1.04	1.06	1.02	1.04	1.05	1.06	1.08

The following parameters are used to adjust the total electricity consumption in the residential sector to electricity use for space conditioning (data from the Residential Energy Consumption Survey (EIA)). A parameter for the commercial sector is used to adjust estimates of commercial electric energy use for Heating, Cooling, & Lighting for new buildings for climate.

July 2002-June 2003 State Heating Degree Days (HDD)					
			Residential		**Commercial**
	HDD65	CDD65	RECS Climate Zone	% electric space conditioning	
NC	3222	1558	4	26.0%	1.1986

Sources: http://lwf.ncdc.noaa.gov/oa/documentlibrary/hcs/hdd.200507-200607.pdf
http://lwf.ncdc.noaa.gov/oa/documentlibrary/hcs/cdd.200501-200607.pdf

Energy Intensity Correction Factor by Climate Zone	
All Buildings	1.1538
>7000 HDD	1.1309
5500-7000	1.2408
4000-5499	1.0297
<4000	1.1986
>2000 CDD & <4000 HDD	1.1953

Household Electricity End Use					
	Climate Zone				
	<2000 CDD				>2000 CDD and <4000 HDD
	>7000 HDD	5500-7000 HDD	4000-5499 HDD	<4000 HDD	
	Quadrillion Btus				
Climate Category	**1**	**2**	**3**	**4**	**5**
Space-Heating	0.03	0.08	0.12	0.08	0.09
Electric AC (central & room)	0.02	0.08	0.11	0.11	0.30
Water Heating	0.04	0.06	0.08	0.07	0.11
Refrigerators	0.04	0.13	0.11	0.10	0.15
Other Appliance & Lighting	0.18	0.52	0.43	0.37	0.48
TOTAL	0.31	0.87	0.85	0.73	1.13
Percent Electric Space Conditioning	**16.1%**	**18.4%**	**27.1%**	**26.0%**	**34.5%**
Source: 2001 RECS (http://www.eia.doe.gov/emeu/recs/recs2001/detailcetbls.html#space)					

Additional Notes

Note 1:

From The Energy Efficiency Task Force Report to the Clean and Diversified Energy Advisory Committee of the Western Governors Association.
The Potential for More Efficient Electricity Use in the Western United States, January, 2006. This report is referred to here as the "WGA CDEAC EE report" and can be found at:
http://www.westgov.org/wga/initiatives/cdeac/Energy%20Efficiency-full.pdf.
The CDEAC report provides a cost of saved energy (electricity) based on an average 7-year payback for code improvements (page 42).

For North Carolina, the equivalent cost is estimated as follows for electricity and natural gas

payback	7	years, from CDEAC report	
lifespan	25	years, conservative assumption	
elec price	**70.40**	$/MWh	see common factors
NG price	**10.18**	$/MMBTU	see common factors

Electricity levelized cost	$34.965	$/MWh
Natural Gas levelized cost	$5.054	$/MMBTU

Note 2:

Based on results from Table 5.8 of the 2002 Energy Consumptions by Manufacturers--Data Tables published by the US Department of Energy's Energy Information Administration, and available as http://www.eia.doe.gov/emeu/mecs/mecs2002/data02/pdf/table5.8_02.pdf, approximately 14% of industrial electricity use in the South Census region is used for HVAC, lighting, and "other facility support", with of natural gas used for HVAC and "other facility support".

In North Carolina, as of 2005, total electricity use by sector was as follows (from Retail Sales of Electricity by State by Sector by Provider, downloaded from http://www.eia.doe.gov/cneaf/electricity/epa/epa_sprdshts.html (file sales_revenue.xls)

	MWh	Fraction of Total
Residential	54,072,734	42%
Commercial	44,161,328	34%
Industrial	30,101,279	23%
Total	128,335,341	100%

Thus industrial use of electricity for non-process uses in North Carolina may be roughly 4.4% of total Residential and Commercial electricity use. This figure is used as an initial rule of thumb in estimating the contribution of savings from this policy from industrial sector measures.

Note 3:

The estimate of 0.3 unit of renovated space per unit of new construction in the commercial sector is a rough assumption.
It is likely that the ratio of commercial space undergoing major renovation to new commerial space will fluctuate year by year. A review of CBECS data (Table B5, see reference in Note 2 for RCI-7) suggests that in the South Atlantic Region renovated space (space renovated since 1980) is about one-third of new commercial building space constructed since 1980.
Some of these renovations likely would not affect building energy performance, but CBECS data suggest that a substantial portion of renovated space involves changes to outside walls and roofs, additions or annexes, or changes to HVAC systems, all of which would seem to be markets for RCI-6.
It is clear that the renovation market represents a substantial opportunity for improving energy efficiency through code changes.
Looking at the few easily accessible studies nationwide, a study of the non-residential renovation market in California (Remodeling and Renovation of Nonresidential Buildings in California, by Donald R. Dohrmann, John H. Reed, Sylvia Bender, Catherine Chappell, and Pierre Landry, available as http://www.energy.ca.gov/papers/2002-08-18_aceee_presentations/PANEL-10_DOHRMANN.PDF) suggests that by 1999 the value of renovations and additions to non-residential space was similar to that in new non-residential space, based on building permit data. As both California and North Carolina include a significant fraction of older buildings in their building stocks, the analogy with California may be reasonable for North Carolina. A study for a Texas building code report, however (see http://www.pnl.gov/main/publications/external/technical_reports/PNNL-15356.pdf) referenced the California report, but concluded that a more appropriate "conservative" value was approximately 20 percent as a long-term national average.

Note 4:

Calculated based on July-2004 to July-2005 estimate of total housing units in North Carolina from http://www.census.gov/popest/housing/HU-EST2005.html (see "2005 Total Housing Units" worksheet in this workbook). Since this figure implicitly nets out demolitions, it may somewhat undercount new units. The source: http://www.census.gov/const/C40/Table2/t2yu200512.txt provides an estimate of 100,220 "New Privately Owned Housing Units Authorized", which may be somewhat of an over-estimate for total new housing units in North Carolina, as it would presumably include some permitted units not ultimately built. We use the former estimate at present as the basis for calculation of future growth in housing units.

Estimate of Mitigation Option Costs and Benefits for North Carolina RCI GHG Analysis

RCI-7 **"Beyond Code" Building Design Incentives and Targets, Incorporating Local Building Materials and Advanced Construction**

Date Last Modified: 5/31/2007 D. Von Hippel/A Bailie

Key Data and Assumptions	2010	2020/all	Units
First Year Results Accrue		2008	

Based on goal set in Mitigation Option Design for RCI-7 (version dated 10/27/06) that reads "Ramp up program starting in 2007 to full effectiveness by 2012, except where noted otherwise".

Electricity	2010	2020/all	Units
Levelized Cost of Electricity Savings		$35	$/MWh
As estimated for RCI-6. Based on 7-year payback as estimated in WGA CDEAC EE Report. (See Note 1 in RCI-6.)			
Levelized Cost of Natural Gas Savings		$5.1	$/MMBtu
As estimated for RCI-6. Based on 7-year payback as estimated in WGA CDEAC EE Report. (See Note 1 in RCI-6.)			
Avoided Electricity Cost		$57	$/MWh
See "AvCost" and "Common Factors" worksheets in this workbook.			
Avoided Natural Gas Cost		$8.0	$/MMBtu
See "NG prices aeo2006" and "Common Factors" worksheets in this workbook.			

Other Data, Assumptions, Calculations	2010	2020/all	Units
Inputs to/Intermediate Results of Calculation of Electricity and Gas Savings			
Average Electricity and Gas Savings Beyond Code Levels (new commercial and residential buildings)	30%	32%	

The description for this option currently includes the following: "5% of new residential buildings and 2% of new commercial buildings annually to go to 'beyond code' energy use levels that improve energy performance over the average new building (that meets the upgraded building code) by 30%...and encourage significant examples throughout the state of various building types that use 50% or less energy than is supported by the existing building code. This is interpreted to mean that participating buildings will be on average 30 percent more efficient than code in 2010, and an estimated average of 32 percent more efficient than code (meaning about 10 percent of participating buildings use 50 percent less energy than code--the "examples" referred to above) in 2020.

Note in particular that the level of savings shown here is beyond that already included in Option RCI-6, and thus already includes an improvement in efficiency relative to average current practice.

Total Commercial Floorspace in North Carolina (million square feet)	2,427	2,780	
Estimated (see "NC_Activities_Est" worksheet in this workbook) based on USDOE EIA CBECS (comercial survey) data for the South Atlantic region, extrapolated using projected North Carolina population as a driver.			
Est. area of new commercial space per year based on (million square feet)	35.7	36.6	
Calculated based on annual floorspace estimates above.			
Total Residential Housing Units in North Carolina	4,358,500	5,210,875	
Assumes 2005 ratio of new homes to increase in population holds through 2020.			
Implied persons per housing units in North Carolina (for reference only)	2.15	2.06	
Estimated number of new residential units per year	86,082	88,377	
Calculated based on estimates above.			
Implied Average Electricity Consumption per Square Foot Commercial Space in North Carolina as of 2005 (see ***Note 2***)		19.59	kWh/yr
Implied Average Natural Gas Consumption per Square Foot Commercial Space in North Carolina as of 2005 (see ***Note 2***)		19.09	kBtu/yr
Implied Average Electricity Consumption per Housing Unit in North Carolina as of 2005 (see ***Note 2***)		13.72	MWh/yr
Implied Average Natural Gas Consumption per Housing Unit in North Carolina as of 2005 (see ***Note 2***)		16.69	MMBtu/yr

NEW BUILDINGS

Electricity Use per New/Renovated Commercial Sq. Ft. After RCI-6 Application *Reduces future per-unit electricity use based on savings from building code improvements (20 percent improvement by 2010) included in RCI-6.*	**16.3**	**16.3**	kWh/yr
Nat. Gas Use per New/Renovated Commercial Sq. Ft. After RCI-6 Application *Assumes the same pattern of code improvement as for electricity use, as described above.*	**15.6**	**15.6**	kBtu/yr
Implied Electricity Use per New/Renovated Commercial Square Foot After RCI-6 Application, Relative to Average in North Carolina as of 2005	**83.0%**	**83.0%**	
Implied Natural Gas Use per New/Renovated Commercial Square Foot After RCI-6 Application, Relative to Average in North Carolina as of 2005	**81.5%**	**81.5%**	
Electricity Use per New/Renovated Residential Unit After RCI-6 Application *Reduces future per-unit electricity use based on savings from building code improvements (20 percent improvement by 2010) included in RCI-6.*	**11.2**	**11.2**	MWh/yr
Natural Gas Use per New/Renovated Residential Unit After RCI-6 Application *Reduces future per-unit electricity use based on savings from building code improvements (20 percent improvement by 2010) included in RCI-6.*	**13.3**	**13.3**	kBtu/yr
Implied Electricity Use per New/Renovated Residential Unit After RCI-6 Application, Relative to Average in North Carolina as of 2005	**81.7%**	**81.7%**	
Implied Natural Gas Use per New/Renovated Residential Unit After RCI-6 Application, Relative to Average in North Carolina as of 2005	**79.4%**	**79.4%**	
Date program of improvement of new buildings fully "ramped up"		2012	
Fraction of new commercial buildings participating in program at full program level		2%	/yr
Fraction of new residential buildings participating in program at full program level		5%	/yr
Implied fraction of new commercial floorspace included in program *Note that government-sector floorspace is covered under RCI-3.*	**1.2%**	**2.0%**	/yr
Implied commercial floorspace included in program (million square feet)	**0.428**	**0.732**	/yr
Implied fraction of new residential units included in program	**3.0%**	**5.0%**	/yr
Implied new residential units included in program	**2,582**	**4,419**	/yr

EXISTING BUILDIINGS

Fraction of existing buildings (buildings existing as of 2005) upgraded under program		20%	
Date by which upgrading goal for existing buildings achieved *Placeholder estimate. The CCAG has requested the TWG to provide this target date.*		2015	
Date program of improvement of existing buildings fully "ramped up" *Assumed same as for new buildings.*		2012	
Fraction of existing buildings (buildings existing as of 2005) upgraded annually from 2012 on: *Adjust until the value at right ~ 0.2 (adjustment for lower penetration during ramp-in period)*	0.199998	3.33%	
Fraction of existing buildings (buildings existing as of 2005) upgraded annually:	**2.0%**	**3.3%**	
Electricity and Gas savings from upgrading existing commercial buildings		20%	
Electricity and Gas savings from upgrading existing residential buildings		15%	

CALCULATION OF SAVINGS

Required Elect/Gas Improvement in New Commercial and Residential Space After RCI-7 Policy Relative to Average in After Application of RCI-6 *Calculated based on inputs above.*	**30.0%**	**32.0%**	
Implied total electricity savings in new commercial buildings from RCI-7 *First-year savings--not cumulative.*	**2.09**	**3.81**	GWh/yr
Implied total gas savings in new commercial buildings from RCI-7 *First-year savings--not cumulative.*	**2.00**	**3.65**	GBtu/yr
Implied total electricity savings in new residential buildings from RCI-7 *First-year savings--not cumulative.*	**8.69**	**15.85**	GWh/yr
Implied total gas savings in new residential buildings from RCI-7 *First-year savings--not cumulative.*	**10.27**	**18.74**	GBtu/yr
Implied total electricity savings in existing commercial buildings from RCI-7 *First-year savings--not cumulative.*	**177**	**294**	GWh/yr
Implied total gas savings in existing commercial buildings from RCI-7 *First-year savings--not cumulative.*	**172**	**287**	GBtu/yr
Implied total electricity savings in existing residential buildings from RCI-7 *First-year savings--not cumulative.*	**162**	**270**	GWh/yr
Implied total gas savings in existing residential buildings from RCI-7 *First-year savings--not cumulative.*	**197**	**329**	GBtu/yr

Average Fraction of Improvement in Electric Energy Intensities from:

Energy Efficiency Improvement	93%	90%
Solar Thermal Energy (hot water/space heat/space cooling)	5%	7%
On-site Solar PV	1%	2%
On-site Biomass/Biogas/Landfill Gas Energy Use	1%	1%
Green Power Purchase (from off-site, beyond electricity supply RPS)	0%	0%

All "placeholder" assumptions, except on-site biomass/biogas/landfill gas energy use calculated so that values sum to 100%.

Average Fraction of Improvement in Gas Energy Intensities from:

Energy Efficiency Improvement	95%	93%
Solar Thermal Energy (hot water/space heat/space cooling)	5%	7%
On-site Solar PV	0%	0%
On-site Biomass/Biogas/Landfill Gas Energy Use	0%	0%
Green Power Purchase (from off-site, beyond electricity supply RPS)	0%	0%

All "placeholder" assumptions, except on-site biomass/biogas/landfill gas energy use calculated so that values sum to 100%.

Adjustment for Inclusion of Rennovated Commercial Space as Well as New Under Program. *Currently set at 1.3 so that about 0.3 unit of renovated space is included per unit of new space (initial assumption). Based on regional and national studies--see Note 3. It may be useful to obtain further NC-specfic information regarding this value if available in the future.*		**1.30**
Adjustment of Energy Use per Unit Floor Area for Commercial Buildings in Program Relative to Average Commercial Building in North Carolina *Placeholder assumption.*	1.00	1.00
Adjustment for Inclusion of Rennovated Residential Units as Well as New Under Program. *Currently set at 1.0 so that no renovated space is included per unit of new space (initial assumption). It may be useful to obtain further NC-specfic information regarding this value.*		**1.00**

Implied Cumulative Impacts of Option, New Commercial Space (Electricity savings)

Energy Efficiency Improvement	5.4	47.0	GWh
Solar Thermal Energy (hot water/space heat/space cooling)	0.3	3.1	GWh
On-site Solar PV	0.1	0.8	GWh
On-site Biomass/Biogas/Landfill Gas Energy Use	0.1	0.5	GWh
Green Power Purchase (from off-site, beyond electricity supply RPS)	-	-	GWh

Implied Cumulative Impacts of Option, New Commercial Space (Natural Gas savings)

Energy Efficiency Improvement	5.4	46.3	GBtu/yr
Solar Thermal Energy (hot water/space heat/space cooling)	0.3	3.0	GBtu/yr
On-site Solar PV	-	-	GBtu/yr
On-site Biomass/Biogas/Landfill Gas Energy Use	0.0	(0.0)	GBtu/yr
Green Power Purchase (from off-site, beyond electricity supply RPS)	-	-	GBtu/yr

Implied Cumulative Impacts of Option, Existing Commercial Space (Electricity savings)

Energy Efficiency Improvement	328.6	2,963.4	GWh
Solar Thermal Energy (hot water/space heat/space cooling)	17.7	194.2	GWh
On-site Solar PV	3.5	48.5	GWh
On-site Biomass/Biogas/Landfill Gas Energy Use	3.5	32.4	GWh
Green Power Purchase (from off-site, beyond electricity supply RPS)	-	-	GWh

Implied Cumulative Impacts of Option, Existing Commercial Space (Natural Gas savings)

Energy Efficiency Improvement	327.0	2,966.2	GBtu/yr
Solar Thermal Energy (hot water/space heat/space cooling)	17.2	189.2	GBtu/yr
On-site Solar PV	-	-	GBtu/yr
On-site Biomass/Biogas/Landfill Gas Energy Use	0.0	(0.0)	GBtu/yr
Green Power Purchase (from off-site, beyond electricity supply RPS)	-	-	GBtu/yr

Implied Cumulative Impacts of Option, New Residential Space (Electricity savings)

Energy Efficiency Improvement	17.6	150.8	GWh
Solar Thermal Energy (hot water/space heat/space cooling)	0.9	9.9	GWh
On-site Solar PV	0.2	2.5	GWh
On-site Biomass/Biogas/Landfill Gas Energy Use	0.2	1.6	GWh
Green Power Purchase (from off-site, beyond electricity supply RPS)	-	-	GWh

Implied Cumulative Impacts of Option, New Residential Space (Natural Gas savings)

Energy Efficiency Improvement	21.6	183.4	GBtu/yr
Solar Thermal Energy (hot water/space heat/space cooling)	1.1	11.7	GBtu/yr
On-site Solar PV	-	-	GBtu/yr
On-site Biomass/Biogas/Landfill Gas Energy Use	0.0	(0.0)	GBtu/yr
Green Power Purchase (from off-site, beyond electricity supply RPS)	-	-	GBtu/yr

Implied Cumulative Impacts of Option, Existing Residential Space (Electricity savings)

Energy Efficiency Improvement	301.7	2,721.3	GWh
Solar Thermal Energy (hot water/space heat/space cooling)	16.2	178.3	GWh
On-site Solar PV	3.2	44.6	GWh
On-site Biomass/Biogas/Landfill Gas Energy Use	3.2	29.7	GWh
Green Power Purchase (from off-site, beyond electricity supply RPS)	-	-	GWh

Implied Cumulative Impacts of Option, Existing Residential Space (Natural Gas savings)

Energy Efficiency Improvement	375.0	3,401.0	GBtu/yr
Solar Thermal Energy (hot water/space heat/space cooling)	19.7	216.9	GBtu/yr
On-site Solar PV	-	-	GBtu/yr
On-site Biomass/Biogas/Landfill Gas Energy Use	0.0	(0.0)	GBtu/yr
Green Power Purchase (from off-site, beyond electricity supply RPS)	-	-	GBtu/yr

Additional Inputs to/Intermediate Results of Costs

Estimated annual levelized cost of solar hot water per unit output	**20.77**	**18.70**	$/MMBtu
Based on inputs to/results of solar hot water heating analysis included in other RCI options.			
Adjustment to solar thermal costs for inclusion of space heat/cooling measures	1.00	1.00	
Placeholder assumption--Value of 1.0 implies that solar space heat and cooling will cost the same per unit output as solar water heating.			
Implied Per Unit Cost Electricity Avoided by Solar WH/SH/Cooling	**65.91**	**59.32**	$/MWh
Implied Per Unit Cost Natural Gas Avoided by Solar WH/SH/Cooling	**14.54**	**13.09**	$/MMBtu
Assumes delivered solar WH/SH/Cooling replaces electric with EF of 0.93, gas with EF of 0.70 (and therefore one MMBtu of delivered solar heat is the equivalent of more than one MMBtu of each fuel).			
Estimated annual levelized cost of on-site Solar PV	**223**	**129**	$/MWh
Based on inputs to/results of solar PV analysis included in 7B-RCI.			
Fuel Cost for On-site Biomass/Biogas/Landfill Gas Energy Use		2.38	$/MMBtu
Based on costs for Biomass fuel, which will likely dominate this category of fuel inputs. See "Common Assumptions" worksheet in this workbook. If significantly processed biomass fuels (such as pelletized fuels) are required, this cost may need to be i			
Relative Efficiency of On-site Biomass/Biogas/Landfill Gas displacing electricity		0.75	
Placeholder assumption.			
Factor to reflect probable higher costs of on-site Biomass/Biogas/Landfill Gas Equipment Relative to Electric Equipment		2.00	
Placeholder assumption--In most cases, heating/water heating equipment designed to use biomass-derived fuels will be more expensive than equipment designed to use electricity. This factor loads these incremental capital costs into estimated fuel costs.			
Implied Per Unit Cost Electricity Avoided by Biomass/Biogas/Landfill Gas	**21.59**	**21.59**	$/MWh
Incremental Cost for Green Power Purchase (from off-site, beyond supply RPS)	25.00	16.71	$/MWh
Placeholder assumption, but should be linked to RCI-9, if necessary.			
Implied use of biomass/biogas/landfill gas by year	**31.84**	**291.42**	Billion Btu

Results	2010	2020	Units
Electricity (Conventional)			
Reduction in Electricity Sales: Residential	343	3,139	GWh (sales)
Reduction in Electricity Sales: Commercial	359	3,290	GWh (sales)
TOTAL Reduction in Electricity Sales	702	6,429	GWh (sales)
Reduction in Generation Requirements	748	6,810	GWh (generation)
GHG Emission Savings	**0.66**	**4.85**	$MMtCO_2e$
Economic Analysis			
Net Present Value (2007-2020)		**-$431**	$million
Cumulative Emissions Reductions (2007-2020)		32.0	$MMtCO_2e$
Cost-Effectiveness		**-$13.47**	$/tCO_2e$
Natural Gas			
Reduction in Gas Use, Residential Sector	417	3,813	
Reduction in Gas Use, Commercial Sector	350	3,205	Billion BTU
TOTAL Reduction in Electricity Sales	767	7,018	
GHG Emission Savings	**0.04**	**0.37**	$MMtCO_2e$
Economic Analysis			
Net Present Value (2007-2020)		**-$64**	$million
Cumulative Emissions Reductions (2007-2020)		2.23	$MMtCO_2e$
Cost-Effectiveness		**-$28.60**	$/tCO_2e$
Biomass/Biogas/Landfill Gas Fuel Use			
Added GHG Emissions from Biomass Fuels Use	**0.00009**	**0.00081**	$MMtCO_2e$
Cumulative added Emissions from Biomass Fuels (2007-2020)		0.0050	$MMtCO_2e$

Summary Results for RCI-7	2010	2020	Units
Total for Option (Natural gas and Electricity less Biomass)			
GHG Emission Savings	**0.70**	**5.22**	$MMtCO_2e$
Net Present Value (2007-2020)		**-$494.2**	$million
Cumulative Emissions Reductions (2007-2020)		34.2	$MMtCO_2e$
Cost-Effectiveness		**-$14.45**	$/tCO_2e$

NOTES AND DATA FROM SOURCES

Note 1:

From The Energy Efficiency Task Force Report to the Clean and Diversified Energy Advisory Committee of the Western Governors Association.
The Potential for More Efficient Electricity Use in the Western United States, January, 2006. This report is referred to here as the "WGA CDEAC EE report" and can be found at:
http://www.westgov.org/wga/initiatives/cdeac/Energy%20Efficiency-full.pdf.
See *Note 1* in RCI-6 worksheet in this workbook.

Note 2:

Based on results from Table B.5 of the 2003 Commercial Buildings Energy Consumption Survey, Detailed Tables dated October 2006 and published by the US Department of Energy's Energy Information Administration, and available as http://www.eia.doe.gov/emeu/cbecs/cbecs2003/detailed_tables_2003/pdf2003/alltables.pdf, as described in "NC_Activities_Est" worksheet in this workbook.

Following data on electricity sales in North Carolina as of 2005 as described in "Utility_Sales" worksheet in this workbook. Downloaded from http://www.eia.doe.gov/cneaf/electricity/epa/epa_sprdshts.html (file sales_revenue.xls)

	MWh	Fraction of Total
Residential	54,072,734	42%
Commercial	44,161,328	34%
Industrial	30,101,279	23%
Total	128,335,341	100%

For natural gas consumpation, consumption data from the USDOE EIA downloaded from http://www.eia.doe.gov/oil_gas/natural_gas/applications/eia176query.html are are follows:
(See "EIA_NG_Data" worksheet in this workbook for raw EIA data)

	Sales (Million Cubic Feet of Natural Gas)			
	Residential	Commercial	Industrial	Total
2005	63,865	41,776	22,956	128,597
Fraction of 2005 Total	50%	32%	18%	100%

Note 3:

The estimate of 0.3 unit of renovated space per unit of new construction in the commercial sector is a rough assumption.
It is likely that the ratio of commercial space undergoing major renovation to new commerial space will fluctuate year by year. A review of CBECS data (Table B5, see reference above) suggests that in the South Atlantic Region renovated space (space renovated since 1980) is about one-third of new commercial building space constructed since 1980. Some of these renovations likely would not affect building energy performance, but CBECS data suggest that a substantial portion of renovated space involves changes to outside walls and roofs, additions or annexes, or changes to HVAC systems, all of which would seem to be markets for RCI-7.
It is clear that the renovation market represents a substantial opportunity for improving energy efficiency through "beyond code" changes.
Looking at the few easily accessible studies nationwide, a study of the non-residential renovation market in California (Remodeling and Renovation of Nonresidential Buildings in California, by Donald R. Dohrmann, John H. Reed, Sylvia Bender, Catherine Chappell, and Pierre Landry, available as http://www.energy.ca.gov/papers/2002-08-18_aceee_presentations/PANEL-10_DOHRMANN.PDF) suggests that by 1999 the value of renovations and additions to non-residential space was similar to that in new non-residential space, based on building permit data. As both California and North Carolina include a significant fraction of older buildings in their building stocks, the analogy with California may be reasonable for North Carolina. A study for a Texas building code report, however (see http://www.pnl.gov/main/publications/external/technical_reports/PNNL-15356.pdf) referenced the California report, but concluded that a more appropriate "conservative" value was approximately 20 percent as a long-term national average.

Estimate of Mitigation Option Costs and Benefits for North Carolina RCI GHG Analysis

RCI-9 Green Power Purchasing (required for State facilities) and Bulk Purchasing Programs for Energy Efficiency or Other Equipment

Date Last Modified:	*6/1/2007 D. Von Hippel/A Bailie*

Key Data and Assumptions	2010	2020/all	Units

Current State/Local Government Building Energy Consumption

Estimated Electricity Purchases (State Govt) in 2005 — **2,040** GWh

Estimate, pending receipt of specific information from State agencies, based on commercial-sector sales in North Carolina, NC-specific estimates of State-owned floorspace, and the ratio of state to local-government floorspace in USDOE EIA CBECS results for the South Atlantic region. See "Utility_Sales", "NC_Activities_Est", and "RCI-3" worksheets in this workbook.

Estimated Electricity Purchases (Local Govt), est. 2005 — **5,839** GWh

Estimate, pending receipt of specific information from State agencies, based on commercial-sector sales in North Carolina, NC-specific estimates of State-owned floorspace, and the ratio of state to local-government floorspace in USDOE EIA CBECS results for the South Atlantic region. See "Utility_Sales", "NC_Activities_Est", and "RCI-3" worksheets in this workbook. Currently only State purchases are included in this Green Power option.

Fraction of statewide commercial sector employment in local government — **20%**

Data for mid-2005, includes "government" (probably state, federal, and local), but excludes educational services. Based on data from the US Bureau of Labor Statistics. See "NC_Activities_Est" worksheet in this workbook. This figure provided for information only.

Rate of growth in state building electricity demand — **0.0%** per year

Assumes that growth in electricity demand is offset by savings from other efficiency/design measures.

Green Power Procurement:

Green Power Purchase (fraction of statewide sales, all sectors), 2006 — **0.016%**

Based on "annual equivalent energy" data for 2006 from most recent quarterly newsletter of North Carolina Greenpower (http://www.ncgreenpower.org/media/newsletters/2006/newsletter_fall2006.html?#update).

Program Start Year — **2008**

Assumed same as start year of renewable energy component of Environmental Portfolio Standard under consideration by CAPAG Energy Supply TWG.

Target Year for Achieving Purchase Level — **2018**

Electricity purchased by state agencies from green (renewable energy) sources in Target Year as a fraction of total state power demand — **20%**

This is an amount OVER AND ABOVE the total renewable energy included in standard purchased electricity. At this level of implementation, in combination with other RCI options and ES options that call for development of renewable-energy-based electricity generation, the total required renewable electricity by 2020 is somewhat less than the "Practical Energy Potential" identified (for example, in Table ES-1) in the report ANALYSIS OF A RENEWABLE PORTFOLIO STANDARD FOR THE STATE OF NORTH CAROLINA, prepared for the North Carolina Utilities Commission by LaCapra Associates, and dated December, 2006. Note that this "Practical Energy Potential" estimate does not include energy from offshore wind power or from solar photovoltaic power.

Fraction of other (all sector) demand adopting state targets — **0.0%**

Implementation measures suggested in the current (10/31/06) version of the RCI-9 description mention incentives provided by the state to induce private sector electricity users to buy green power. No specific goals for doing so, however, are provided at present. This figure is thus set to zero as a placeholder value, pending TWG input.

Incremental Cost of Green Power — **$ 25.00** | $ 16.71 /MWh

This represents the approximate added consumer cost of green power, assuming bulk purchase (see e.g. NC GreenPower program at http://www.ncgreenpower.org/about/index.html where bulk purchases of over 10 MWh pay $25/MWh), and assumes that bulk purchase costs will fall by 2017 to the level of the average net cost of renewable generation calculated from data from a report on the prospects for renewable generation in North Carolina by La Capra Associates (see "La_Capra_Data" worksheet in this workbook). The incremental cost of green power is assumed to stay constant (in real terms) after 2017. This is a rough approximation. The incremental cost (and cost-effectiveness) of this measure may also be reflected in the cost of the RPS policy (see ES group), since it considers costs at the wholesale not retail level, from an economic rather than financial perspective.

Bulk Purchase Program:

Fraction of State agency electricity demand addressed by bulk purchasing program — **10%**

Placeholder estimate.

Fraction of all-sector (excluding government) electricity demand addressed by bulk purchasing program — **1%**

Placeholder estimate.

Average lifetime of devices included in bulk purchasing program — **10** years

Placeholder estimate--designed to be an average between longer-lived equipment such as water heaters and air conditioners, and shorter-lived devices such as computers.

Fractional savings from bulk purchase program relative to standard-efficiency equipment, appliances, and other devices. — **20%**

Placeholder estimate, but consistent with an average of fractional savings possible with many different types of higher-than-standard efficiency appliances, equipment, and other devices.

Assumed Cost of Bulk Purchase Program Savings — **$12** $/MWh

Pending receipt of more specific information, assumed to be similar to the cost of market transformation programs. Figure used is the same as used in RCI-4 worksheet in this workbook (From WGA EE Task Force study (2005), which cites the Retrospective Analysis of the Northwest Energy Efficiency Alliance (Violette, Ozog, and Cooney, 2003).)

Program Start Year — **2010**

Assumed same as for Green Power Component.

Target Year for Achieving Purchase Level — **2018**

Assumed same as for Green Power Component.

Avoided Electricity Cost — **$57** $/MWh

See common assumptions.

Other Data, Assumptions, Calculations	2010	2020/all	Units
North Carolina All-Sector Electricity Use	134,876	159,498	
See RCI-1 (figures based on 2005 utility sales and forecast prepared for CAPAG process).			
Fraction of electricity from green (renewable energy) sources by year	5.5%	20.0%	
State Building Electricity Use	2,040	2,040	GWh
Net of efficiency measures from other programs and options. Does not currently include local government electricity use.			
Fractional implementation of Bulk Purchase Program targets	11.1%	100.0%	
Annual Savings from Bulk Purchase Program (not cumulative)			
State Agency Program	0.5	4.1	GWh
All-sectors (non-State) Program	3.0	31.5	GWh

Results	2010	2020	Units
Green Power			
Green Power Purchased, Current Programs, All Sectors	21.0	24.8	GWh (sales)
Green Power Requirement, Current Programs, All Sectors	22.3	26.4	GWh (generation)
GHG Emission Savings	0.020	0.019	$MMtCO_2e$
Green Power Purchased, Expanded Program	111	408	GWh (sales)
Green Power Requirement, Expanded Programs	118	434	GWh (generation)
GHG Emission Savings	0.10	0.31	$MMtCO_2e$
Economic Analysis			
Net Present Value (2007-2020)		$37	$million
Cumulative Emissions Reductions (2007-2020)		2.7	$MMtCO_2e$
Cost-Effectiveness		$13.7	$/tCO_2e$
Bulk Purchase Program:			
Savings from Bulk Purchase Program, All Sectors	3	237	GWh (sales)
Savings from Bulk Purchase Program, All Sectors	4	252	GWh (generation)
GHG Emission Savings	0.00	0.17	$MMtCO_2e$
Economic Analysis			
Net Present Value (2007-2020)		-$26	$million
Cumulative Emissions Reductions (2007-2020)		0.8	$MMtCO_2e$
Cost-Effectiveness		-$34.0	$/tCO_2e$

Summary Results for RCI-9	2010	2020	Units
Total for Option (Green Power and Bulk Purchase Programs)			
GHG Emission Savings	0.11	0.48	$MMtCO_2e$
Net Present Value (2007-2020)		$10.7	$million
Cumulative Emissions Reductions (2007-2020)		3.5	$MMtCO_2e$
Cost-Effectiveness		$3.07	$/tCO_2e$

Estimate of Mitigation Option Costs and Benefits for North Carolina RCI GHG Analysis

RCI-10 **Distributed Renewable and Clean Fossil Fuel Power Generation**

Date Last Modified: 6/5/2007 D. Von Hippel/A Bailie

Key Data and Assumptions	2010	2020/all	Units
First Year Results Accrue		2008	
Avoided Electricity Cost		$57	$/MWh
Weighted average over total 2007-2020 electricity savings for this policy in each sector. See common assumptions ("Common Factors" worksheet in this workbook).			
Avoided Natural Gas Cost		$8.0	$/MMBtu
See common assumptions ("Common Factors" worksheet in this workbook)			
Avoided LPG Cost		$12	$/MMBtu
See common assumptions ("Common Factors" worksheet in this workbook)			
Target Year for Reaching Solar Hot Water (SHW) Implementation Level		2020	
Fraction of additional existing North Carolina Homes with Solar HW by Target Year		3%	
Option Design states "An additional 2 to 4 percent of all NC homes will have SHW installations by 2020." Midpoint of range chosen.			
Target Year for Reaching Combined Heat and Power (CHP) Implementation Level		2020	
Fraction of additional NC CHP Implementation Potential Achieved by Target Year		29%	
Option Design states "Implementation of 25-33% of North Carolina's CHP potential by 2020". Midpoint of range chosen.			
Target Year for Reaching Distributed Renewable Generation Implementation Level		2020	
Additional NC Renewable Distributed Generation Achieved by Target Year		35	MW
Option Design states "35 additional MW of distributed renewable generation over and above RPS-related new generation by 2020", but also, "The CAPAG suggests that the TWG consider 'tightening up this target and going further'".			

Other Data, Assumptions, Calculations	2010	2020/all	Units
Residential Sector Water Heating			
Number of Total Housing Units in North Carolina (thousand)	4,358,500	5,210,875	
Assumes 2005 ratio of new homes to increase in population holds through 2020.			
Fraction of Additional Housing Units Solar Water Heat through Program	0.7%	3.0%	
Fraction of Housing Units Using Non-Solar Water Heat In Absence of Program			
Fraction Using Electricity	35.0%	34.9%	
Fraction Using Natural Gas	65.0%	65.1%	
Fraction Using LPG	5.0%	5.0%	
Fraction Using Solar (alone or with back-up, before policy)	5.0%	5.0%	
Rough Estimates Pending Receipt of State-Specific Data.			

Use of Electricity and Other (non-solar) Energy Sources per (non-solar) Household in Absence of Program

Electricity	**4,000**	**3,810**	kWh
Natural Gas	18.13	17.27	MMBtu
LPG	18.13	17.27	MMBtu

Value for 2010 assumes 4000 kWh per HH using electricity for water heat, which is a rough estimate pending receipt of state-specific data. Estimates for gas and lpg base on average EF of .93 for Electricity, .7 for Natural Gas/LPG. Value in 2020 assumes 5% reduction in water heating energy use between 2010 and 2020 due to reduction in number of people per household plus naturally occuring energy efficiency improvements.

Additional Households Using Solar HW Under Program (thousand)	30.2	156.3
Fraction of household hot water needs provided by solar HW units	**80.0%**	**85.0%**

Placeholder Assumption--Back-up fuels used for water heating in housing units with solar water heating are assumed to be distributed based on the pre-Policy fractions given above.

Savings of Electricity and Other (non-solar) Energy Sources Due to Program

Electricity	35.6	186.2	GWh
Natural Gas	0.285	1.493	TBtu
LPG	0.022	0.115	TBtu

Incremental Capital Cost of Solar Water Heater (relative to electric or gas unit)	**$3,500**	**$3,000**

Placeholder Assumption, pending receipt of NC-specific data.

Implied Cumulative Additional Annualized Capital Costs for Residential Solar Hot Waters Installed as a Result of Policy (thousand 2005 dollars)	**$ 7,178**	**$ 34,715**

Factors for Annualizing Capital Costs (Residential Solar Hot Water Systems)

Interest Rate (real)	7%	/yr
Economic Life of System	20	years
Implied Annualization Factor	9.44%	%/yr
Marginal Federal Tax Rate, Residential	28%	

Federal Solar Tax Credits: Residential Sector--See ***Note 3***	0%	0%

Reduce Captial Costs for Solar Tax Credits and Federal Mortgage Deductions?	**YES**

Used for both Residential and Commercial Sectors

Intermediate Results: Residential SWH Program

Reduction in Electricity Sales from SWH Program: Residential	36	186	GWh (sales)
Reduction in Generation Requirements	38	197	GWh (generation)
GHG Emission Savings	**0.03**	**0.14**	$MMtCO_2e$

Economic Analysis (for Electricity Savings due to SWH Program)

Net Present Value (2007-2020)	**$5.8**	$million
Cumulative Emissions Reductions (2007-2020)	1.0	$MMtCO_2e$
Cost-Effectiveness	**$5.80**	$/tCO_2e$

Natural Gas

Savings due to Implementation of SWH Program

Reduction in Gas Use	494	1,493	Billion BTU
GHG Emission Savings	0.03	0.08	$MMtCO_2e$

Economic Analysis (for Gas Savings due to SWH Program)

Net Present Value (2007-2020)	**$41.4**	$million
Cumulative Emissions Reductions (2007-2020)	0.51	$MMtCO_2e$
Cost-Effectiveness	**$81.88**	$/tCO_2e$

LPG

Savings due to Implementation of SWH Program

Reduction in Gas Use	38	115	Billion BTU
GHG Emission Savings	0.00	0.01	$MMtCO_2e$

Economic Analysis (for LPG Savings due to SWH Program)

Net Present Value (2007-2020)	**$1.2**	$million
Cumulative Emissions Reductions (2007-2020)	0.047	$MMtCO_2e$
Cost-Effectiveness	**$26.24**	$/tCO_2e$

Commercial and Industrial Combined Heat and Power

North Carolina Potential for Combined Heat and Power as of 2000		3,545	MW
*Estimated based on older "Onsite Sycom" documents; see **Note 1**. May be revisited if more current and NC-specific data are available.*			
Estimated Future North Carolina Potential for Combined Heat and Power	3,811	4,417	MW
Potential assumed to scale with forecast commercial plus industrial electricity sales.			
Fraction of Potential Installed Under Program (Cumulative)	6.7%	29.0%	
MW CHP Installed Under Program (annual installations)	87	116	MW
Average full-capacity-equivalent hours of operation for New CHP units: *(Assumption)*	**5,000**	**5,000**	
Fraction of New CHP Capacity/Energy Fueled With:			
Natural Gas	90%	82.5%	
Biomass	6%	17.5%	
Coal	4%	0.0%	

Targets; for biomass (including biomass generation capacity included under "distributed generation", below), goal is to provide approximately 750 GWh by 2020, or about 10 percent of "practical potential" for biomass-fueled power (not co-fired) as indicated in the "La Capra Report" (page 19). The 953 MW of potential biomass-fueled generation, assuming the same 90% capacity factor assumed by La Capra, suggests a total potential generation of ABOUT 7500 GWh. See below for full reference to LaCapra Report.

Implied Annual New CHP Capacity by Fuel (MW)		
Natural Gas	**78.42**	**95.88**
Biomass	**5.23**	**20.34**
Coal	**3.49**	**-**
Implied Cumulative New CHP Capacity by Fuel (MW)		
Natural Gas	**229.57**	**1,108.69**
Biomass	**15.30**	**144.59**
Coal	**10.20**	**27.68**
Implied Cumulative New CHP Electricity Output by Fuel (GWh)		
Natural Gas	**1,148**	**5,543**
Biomass	**77**	**723**
Coal	**51**	**138**
Average Net Heat Rate by Fuel (Btu Fuel Input/kWh Electricity Output)		
Natural Gas	10,000	10,000
Biomass	13,500	13,500
Coal	12,000	12,000

*Rough estimates, as heat rates vary by installation. Heat rates for natural gas-fueled units consistent with values from AEO report provided in **Note 7**, below.*

Implied Fuel Input by Fuel (Billion Btu)		
Natural Gas	**11,478**	**55,435**
Biomass	**1,033**	**9,760**
Coal	**612**	**1,661**
Usable Cogenerated Heat Output as a Fraction of Fuel Energy Input		
Natural Gas	40%	40%
Biomass	40%	40%
Coal	40%	40%
Implied Usable Heat Output by Fuel (Billion Btu)		
Natural Gas	**4,591**	**22,174**
Biomass	**413**	**3,904**
Coal	**245**	**664**
Fraction of Usable Heat Output Replacing Space/Water/Process Heat Use *(Assumption)*	90%	90%
Fraction of CHP Heat Output Displacing Thermal Energy Produced Using		
Natural Gas	45%	45%
Biomass	7%	7%
Coal	5%	5%
Electricity	22%	22%
Oil	21%	21%

Assumptions based roughly on forecast commercial plus industrial sector demand for these fuels as of 2015.

Net Efficiency of Displaced Boiler/Heater Thermal Energy Produced Using

Natural Gas	85%	85%
Biomass	80%	80%
Coal	80%	80%
Electricity	92%	92%
Oil	80%	80%

Assumptions

Net Displaced Fuel Use (Billion Btu)

Natural Gas	**2,501**	**12,742**
Biomass	**413**	**2,106**
Coal	**295**	**1,504**
Electricity	**1,130**	**5,755**
Oil	**1,240**	**6,318**

Inputs to Cost Estimates for CHP Systems

Estimated Average Installed Capital Costs by System Type ($2005/kW)

Natural Gas	$ 1,500	$ 1,100
Biomass	$ 2,400	$ 2,000
Coal	$ 2,200	$ 2,000

For biomass systems, this value is somewhat less than the cost of wood-fired (electricity-only) systems as described on page 117 of the "LaCapra Report", ANALYSIS OF A RENEWABLE PORTFOLIO STANDARD FOR THE STATE OF NORTH CAROLINA, TECHNICAL REPORT, prepared by La Capra Associates for the North Carolina Utilities Commission, and dated December, 2006 (document available as http://www.ncuc.commerce.state.nc.us/rps/NC%20RPS%20Report%2012-06.pdf), but at the high end of the range of costs given in the presentation "Biomass to Energy:Present Commercial Strategies and Future Options", by John Scahill of the NREL National Bioenergy Center (dated January, 2003). The latter document includes a projection of a decline in biomass generation costs over time. Costs for natural gas systems are a very rough average over a range of possible technologies and capacities that are used in the commercial and industrial sectors. Sources include the AEO2007 data listed in ***Note 7****, below, and the two older ONSITE-SYCOM studies also listed in Note 8. Costs for coal-fired systems are rough estimates at present.*

Factors for Annualizing Capital Costs (all plant types)

Interest Rate	8%	/yr
Economic Life of System	20	years
Implied Annualization Factor	10.19%	%/yr

Estimated Average Non-fuel Operating and Maintenance Costs by System Type ($/MWh)

Natural Gas	$ 10.00	$ 10.00
Biomass	$ 25.00	$ 20.00
Coal	$ 20.00	$ 20.00

For biomass systems, similar to sum of fixed and viabled O&M costs for wood-fired (electricity-only) systems as described on page 1187 of the "LaCapra Report" referenced above. Natural gas O&M costs vary by system size and type. Value shown here is a rough estimate based on data in the Onsite/Sycom reports referenced in Note 1 and in other sources. O&M costs for coal-fired plants are rough estimates.

Intermediate Results for Cost Estimates

Total Capital Costs for New Systems (thousand 2005 dollars)

Natural Gas	$ 117,633	$ 105,467
Biomass	$ 12,548	$ 40,676
Coal	$ 7,668	$ -

Annualized Capital Costs for All Systems (thousand 2005 dollars)

Natural Gas	$ 35,073	$ 149,079
Biomass	$ 3,741	$ 31,926
Coal	$ 2,286	$ 6,067

Annual Non-Fuel Operating and Maintenance Costs for All Systems (thousand 2005 dollars)

Natural Gas	$ 11,478	$ 55,435
Biomass	$ 1,913	$ 14,459
Coal	$ 1,020	$ 2,768

Total Non-Fuel Costs for All Systems (thousand 2005 dollars)

Natural Gas	$ 46,551	$ 204,514
Biomass	$ 5,654	$ 46,385
Coal	$ 3,307	$ 8,834

Total Gross Fuel Costs for All Systems (thousand 2005 dollars)

Natural Gas	$ 90,606	$ 429,654
Biomass	$ 2,460	$ 23,244
Coal	$ 1,493	$ 4,051

Evaluated based on avoided costs estimates--See "Common Factors" worksheet in this workbook.

Total Fuel Cost Savings from Displaced Heating Fuels for All Systems (thousand 2005 dollars)

Natural Gas	$ 19,744	$ 98,757
Biomass	$ 985	$ 5,016
Coal	$ 720	$ 3,669
Electricity	$ 18,757	$ 95,555
Oil	$ 16,587	$ 84,497

Evaluated based on avoided costs estimates--See "Common Factors" worksheet in this workbook.

Intermediate Results: Commercial/Industrial CHP

Electricity

TOTAL Reduction in Electricity Sales (electricity output from CHP plus avoided electricity use in boilers/space heaters/water heaters)	1,606	8,092	GWh (sales)
Reduction in Generation Requirements	1,710	8,572	GWh (generation)
Gross GHG Emission Savings	**1.50**	**6.11**	$MMtCO_2e$

Natural Gas

Net Change in Gas Use (negative values denote increased use)	-8,977	-42,693	Billion BTU
Net GHG Emissions (negative values denote increased emissions)	-0.47	-2.22	$MMtCO_2e$

Biomass

Net Change in Biomass Use (negative values denote increased use)	-620	-7,654	Billion BTU
Net GHG Emissions (negative values denote increased emissions)	-0.002	-0.021	$MMtCO_2e$

Coal

Net Change in Coal Use (negative values denote increased use)	-317	-157	Billion BTU
Net GHG Emissions (negative values denote increased emissions)	-0.03	-0.01	$MMtCO_2e$

Oil

Net Change in Oil Use (negative values denote increased use)	1,240	6,318	Billion BTU
Net GHG Emissions (negative values denote increased emissions)	0.09	0.47	$MMtCO_2e$

Total for CHP Program (All Fuels)

Total Net GHG Emission Savings	**1.10**	**4.32**	$MMtCO_2e$
Net Present Value (2007-2020)		**$312**	$million
Cumulative Emissions Reductions (2006-2020)		31.4	$MMtCO_2e$
Cost-Effectiveness		**$9.93**	$/tCO_2e$

Renewable Distributed Generation (DG)

Total Additional Capacity of Renewable DG Built under Program	8.1	35.0	MW
Annual Additional Capacity of Renewable DG Built under Program	2.7	2.7	MW
Fraction of Additional Capacity As			
Residential PV Systems	35%	40%	
Commercial PV Systems	35%	40%	
Customer-sited Landfill Gas	10%	5%	
Customer-sited Biomass	15%	12%	
Customer-sited Biogas	5%	3%	
Average Capacity of Solar PV System Installed on Homes (kW)	**3.00**	**3.00**	

*Assumption, consistent with capacity assumption used in Source in **Note 2**.*

Average Capacity of Solar PV System Installed on Commercial Buildings (kW)	**20.00**	**20.00**

*Assumption, roughly consistent, per square foot of floor area, with capacity assumptions for new and existing residential buildings used in Source in **Note 2**. See also **Note 6** for calculation of average floor area of commercial builidngs.*

Number of Homes Installing Solar PV Systems Annually	**314**	**359**

Total Number of Homes with Solar PV Systems Installed under this Option,
2008 to 2020: 4,330

*Note that a cummulative ~4,300 solar PV systems by 2020 is considerably less, on a per-capita basis, than the 1.2 million solar homes by 2020 used in an estimate of solar PV contributions to GHG emissions reduction in California (see **Note 2**).*

Implied number of Commercial Solar PV Systems Added Annually	**47**	**54**

Calculated based on target capacity and capacity-per-building assumption above.

Total Annual Residential Solar PV Capacity Installed on Homes (MW)	**0.94**	**1.08**
Total Annual Commercial Solar PV Capacity Installed (all Buildings) (MW)	**0.94**	**1.08**
Estimated Annual Total Solar PV Installed Under Policy by Year (MW)	**1.88**	**2.15**
Estimated Cumulative Total Solar PV Installed Under Policy by Year (MW)	**5.65**	**25.98**
Average full-capacity-equivalent hours of operation for Solar PV Systems:	**1,691**	**1,691**

*Based on data for Raleigh in figure in guide document from North Carolina Solar Center--See **Note 4**.*

Implied New Solar PV Output, Cumulative Systems (GWh)	**10**	**44**
Implied Annual New Biomass/Landfill Gas/Biogas-fueled Capacity by Fuel (MW)		
Landfill Gas	**0.27**	**0.13**
Biomass	**0.40**	**0.32**
Biogas	**0.13**	**0.08**
Implied Cumulative New Biomass/Landfill Gas/Biogas-fueled Capacity by Fuel (MW)		
Landfill Gas	**0.81**	**2.76**
Biomass	**1.21**	**4.81**
Biogas	**0.40**	**1.45**
Average Full-capacity-equivalent Hours of Operation for Systems Above:	**5,000**	**5,000**

Placeholder Assumptions

Implied Cumulative New Biomass/Landfill Gas/Biogas-fueled Electricity Output by Fuel (GWh)		
Landfill Gas	**4.0**	**13.8**
Biomass	**6.1**	**24.0**
Biogas	**2.0**	**7.3**
Average Net Heat Rate by Fuel (Btu Fuel Input/kWh Electricity Output)		
Landfill Gas	10,000	10,000
Biomass	12,500	12,500
Biogas	10,000	10,000

*Rough estimates, as heat rates vary by installation. Heat rates for landfill and biogas-fueled units consistent with values for natural gas CHP from AEO report provided in **Note 7**, below.*

Implied Fuel Input by Fuel (Billion Btu)		
Landfill Gas	**40**	**138**
Biomass	**76**	**300**
Biogas	**20**	**73**

Inputs to Cost Estimates for Solar PV Systems (Data from Source in *Note 3*)

Capital Costs for PV Systems for Homes		
Module	$ 3,749	$ 2,245
BOS (Balance of System)	$ 1,250	$ 748
Installation	$ 903	$ 315
Total System - $/kW	$ 5,902	$ 3,308
Total System - $	$ 17,706	$ 9,924
Commercial System Capital costs/kW Relative to New Residential	80%	80%
*Rough assumption, but similar to values in literature--See **Note 5**.*		
Solar PV Operating and Maintenance (O&M) Costs ($/MWh)	$ 5.88	$ 5.88
*Rough assumption--See **Note 6**.*		
Federal Solar Tax Credits: Residential Sector--See ***Note 3***	0%	0%
Federal Solar Tax Credits: Commercial and Industrial Sectors--See ***Note 3***	10%	10%

Factors for Annualizing Capital Costs (Residential PV Systems)		
Interest Rate	7%	/yr
Economic Life of System	20	years
Implied Annualization Factor	9.44%	%/yr
Marginal Federal Tax Rate, Residential	28%	
Factors for Annualizing Capital Costs (Commercial PV Systems)		
Interest Rate	8%	/yr
Economic Life of System	20	years
Implied Annualization Factor	10.19%	%/yr
Reduce Captial Costs for Solar Tax Credits and Federal Mortgage Deductions?	YES	

Intermediate Results for Solar PV System Cost Estimates

Total Capital Costs for New Systems (thousand 2005 dollars) Net of Tax Credits		
Systems for Residences	$ 5,562	$ 3,562
Systems for Commercial Installations	$ 4,004	$ 2,565
Annualized Capital Costs for All Systems (thousand 2005 dollars)		
Systems for Residences	$ 1,205	$ 4,185
Systems for Commercial Installations	$ 1,301	$ 4,515
Annual Operating and Maintenance Costs for All Systems (thousand 2005 $)	$ 56	$ 258

Inputs to Cost Estimates for Biomass/Landfill Gas/Biogas-fueled Systems

Estimated Average Installed Capital Costs by System Type ($2005/kW)		
Landfill Gas	$ 1,700	$ 1,200
Biomass	$ 2,400	$ 2,000
Biogas	$ 1,700	$ 1,200

Estimates for Landfill Gas and Biogas plants assume slightly higher costs than for gas-fired CHP due to the need for equipment to purify incoming fuel gas. Biomass plant costs assumed the same as biomass CHP costs.

Factors for Annualizing Capital Costs (all plant types)		
Interest Rate	8%	/yr
Economic Life of System	20	years
Implied Annualization Factor	10.19%	%/yr

Estimated Average Non-fuel Operating and Maintenance Costs by System Type ($/MWh)		
Landfill Gas	$ 20.00	$ 20.00
Biomass	$ 25.00	$ 25.00
Biogas	$ 20.00	$ 20.00

Placeholder Assumptions

Intermediate Results for Biomass/Landfill Gas/Biogas-fueled Cost Estimates

Total Capital Costs for New Systems (thousand 2005 dollars)		
Landfill Gas	$ 458	$ 162
Biomass	$ 969	$ 646
Biogas	$ 229	$ 97
Annualized Capital Costs for All Systems (thousand 2005 dollars)		
Landfill Gas	$ 140	$ 471
Biomass	$ 296	$ 1,162
Biogas	$ 70	$ 248
Annual Non-Fuel Operating and Maintenance Costs for All Systems (thousand 2005 dollars)		
Landfill Gas	$ 81	$ 276
Biomass	$ 151	$ 601
Biogas	$ 40	$ 145
Total Non-Fuel Costs for All Systems (thousand 2005 dollars)		
Landfill Gas	$ 221	$ 747
Biomass	$ 448	$ 1,762
Biogas	$ 110	$ 393
Total Fuel Costs for All Systems (thousand 2005 dollars)		
Landfill Gas	$ 202	$ 690
Biomass	$ 180	$ 715
Biogas	$ 101	$ 363

Intermediate Summary Results for Renewable Distributed Generation Program

Total Electricity Output	21.7	89.0
Total Cost (thousand 2005 dollars, net of value of electricity output)	$ 2,054	$ 6,097

Results	2010	2020	Units
Savings due to Implementation of RCI-10 Programs			
Electricity			
TOTAL Reduction in Electricity Sales (savings from SWH/CHP plus electricity output from CHP/Solar PV and landfill gas/biomass/biogas systems)	1,664	8,367	GWh (sales)
Reduction in Generation Requirements	1,771	8,864	GWh (generation)
Gross GHG Emission Savings	**1.56**	**6.32**	$MMtCO_2e$
Natural Gas			
Net Change in Gas Use (negative values denote increased use)	-8,693	-41,200	Billion BTU
Net GHG Emissions (negative values denote increased emissions)	-0.45	-2.15	$MMtCO_2e$
LPG			
Net Change in Gas Use (negative values denote increased use)	22	115	Billion BTU
Net GHG Emissions (negative values denote increased emissions)	0.00	0.01	$MMtCO_2e$
Coal			
Net Change in Coal Use (negative values denote increased use)	-317	-157	Billion BTU
Net GHG Emissions (negative values denote increased emissions)	-0.03	-0.01	$MMtCO_2e$
Oil			
Net Change in Oil Use (negative values denote increased use)	1,240	6,318	Billion BTU
Net GHG Emissions (negative values denote increased emissions)	0.09	0.47	$MMtCO_2e$
Landfill Gas			
Net Change in Gas Use (negative values denote increased use)	-40	-138	Billion BTU
Net GHG Emissions (negative values denote increased emissions)	0.0000	0.0000	$MMtCO_2e$
Biomass			
Net Change in Biomass Use (negative values denote increased use)	-695	-7,954	Billion BTU
Net GHG Emissions (negative values denote increased emissions)	-0.002	-0.022	$MMtCO_2e$
Biogas			
Net Change in Gas Use (negative values denote increased use)	-20	-73	Billion BTU
Net GHG Emissions (negative values denote increased emissions)	0.0000	0.0000	$MMtCO_2e$

Summary Results for RCI-10		2010	2020	Units
Total for Policy (Electricity, Natural Gas, LPG, Oil, Landfill Gas, Biomass, Biogas)				
GHG Emission Savings		**1.17**	**4.61**	$MMtCO_2e$
Net Present Value (2007-2020)			**$392**	$million
Cumulative Emissions Reductions (2007-2020)			**33.5**	$MMtCO_2e$
Cost-Effectiveness			**$11.71**	$/tCO_2e$

NOTES AND DATA FROM SOURCES

Note 1:

Following data from
ONSITE SYCOM Commercial CHP Report - Appendix B-2 [presumably for year 2000]
Report title: The Market and Technical Potential for Combined Heat and Power in the Commercial/Institutional Sector
Prepared for the U.S. Department of Energy Energy Information Administration, dated January, 2000.

	Potential (MW) by Size Class				
State	*100-500 kW*	*500-1000 kW*	*1 - 5 MW*	*> 5 MW*	*Total*
North Carolina	800.4	719.6	622.1	265.6	2,408

Lacking (to date) an independent estimate of the CHP potential for the Industrial sector in NC, the approach here is to start with an estimate for the overall CHP potential in different size classes nationwide, prepared for the USDOE Energy Information Administration by ONSITE SYCOM Energy, January 2000) then estimate the remaining potential in NC based on the fraction of national industrial-sector electricity use that occurs in the State.

Total US electricity sales to Industrial Customers, 2000:	1,064,239,391	GWh
Total NC electricity sales to Industrial Customers, 2000:	34,251,860	GWh (estimated in workbook
Implied NC fraction of US industrial electricity use:	3.22%	

From data on electricity sales in North Carolina and the US as of 2000 as described in "Utility_Sales" worksheet in this workbook.
Downloaded from http://www.eia.doe.gov/cneaf/electricity/epa/epa_sprdshts.html (file sales_revenue.xls)

Data in the ONSITE SYCOM Industrial CHP report suggests that NC had an installed CHP base of 1258 MW as of about 2000, of which very little appeared to be in units under 10 MW in capacity (tables 2.10, 2.11), since the total capacity was spread among only 33 units.

Following Data from Table 3.3 of ONSITE SYCOM report:

CHP Size Class	US Techical Potential for Industrial CHP (MW)	Implied NC Techical Potential for CHP (MW)	Estimated Existing NC CHP (MW)	Implied Remaining NC Potential for CHP (MW)
< 1 MW	21,990	707.73		
1 - 4 MW	6,439	207.24		
4 - 20 MW	13,779	443.47		
20 - 50 MW	13,799	444.11		
> 50 MW	35,361	1,138.07		
TOTAL	91,368	2,941	1,258	1,682.62
Less estimated fraction over 10 MW	56,050	1,803.92	1,258	545.92
Net under 10MW	35,319	1,136.70	-	1,137

Note 2:

Source: Worksheet "Solar Homes Summary table.xls", with calculations in support of the California Million Solar Homes Initiative, authored by XENERGY, Inc., and provided by M. Lazarus. Selected annual data provided.

Note 3:

A description of the new Federal Solar Tax Credits for businesses and residences as contained in the Energy Policy Act of 2005 (EPAct 2005) (see, for example, http://www.seia.org/getpdf.php?iid=21) provides for 30% (of system cost) tax credits for solar PV investments by businesses in 2006 and 2007, reverting to 10% thereafter. For residences, the credit in 2006 and 2007 is 30% with a "cap" of $2000, reverting to zero after 2007. For the purpose of this analysis, we are modeling the federal tax credit at its long-term (10% business, 0% residential) level, as no systems are added in 2006 and 2007.
See also, for Example,
http://www.sdenergy.org/uploads/PV-Federal%20Tax%20Credits%20Summary%206-01-04%20FINAL.pdf.

Note 4:
Source: North Carolina Consumer's Guide to Buying a Solar Electric System, From NC Solar Center, http://www.ncsc.ncsu.edu/information_resources/factsheets/cnsmrguide.pdf.

Note 5:
Source: International Energy Agency (IEA), TRENDS IN PHOTOVOLTAIC APPLICATIONS
Survey report of selected IEA countries between 1992 and 2004. Report #IEA-PVPS T1-14:2005.
Page 18.
"Indicative costs" in 2004 in USD per kWp (assumedly DC output) for on-grid PV systems in the US:

<10 kW	7000 to 10,000
>10 kW	6300 to 8500

In EIA Projections of Renewable Energy Costs, presented in "Forum on the Economic Impact Analysis of NJ's Proposed 20% RPS" by Chris Namovicz of the USDOE EIA (Energy Information Administration), dated February 22, 2005, and available as http://www.eia.doe.gov/oiaf/pdf/rec.pdf, a PV power average cost of
6000 dollars/kW is provided for a 25 kW Commercial system, or
8200 dollars/kW for a 2 kW Residential system, with
"Large potential for cost reduction".

Note 6:
An older (1997) US DOE document OVERVIEW OF PHOTOVOLTAIC TECHNOLOGIES
(available as http://www.eere.energy.gov/ba/pdfs/pv_overview.pdf) suggests that even early solar PV systems had O&M costs of under $ 0.005 per kWh, which in 2005 dollars would be: $ 0.0059 per kWh.

Note 7:
From *Assumptions for the Annual Energy Outlook 2007*
USDOE Energy Information Administration 2007
tonto.eia.doe.gov/FTPROOT/forecasting/0554(2007).pdf

Data for Commercial sector (p. 34)

Table 13. Capital Cost and Performance Parameters of Selected Commercial Distributed Generation Technologies

Technology Type	Year	Average Generating Capacity (kW)	Electrical Efficiency	Combined Efficiency (Elec.+ Thermal)	Installed Capital Cost ($2005 per kW of Capacity)*	Service Life (Years)
Solar Photovoltaic	2005	30	0.16	N/A	$5,350	30
	2010	32	0.18	N/A	$4,045	30
	2015	35	0.2	N/A	$3,800	30
	2020	40	0.22	N/A	$3,714	30
	2025	40	0.22	N/A	$3,451	30
	2030	45	0.25	N/A	$3,015	30
Fuel Cell	2005	200	0.36	0.72	$5,946	20
	2010	200	0.44	0.66	$5,466	20
	2015	200	0.45	0.67	$5,203	20
	2020	200	0.47	0.69	$4,187	20
	2025	200	0.48	0.7	$3,674	20
	2030	200	0.49	0.72	$3,108	20
Natural Gas Engine	2005	300	0.31	0.77	$2,132	20
	2010	300	0.32	0.78	$1,878	20
	2015	300	0.32	0.78	$1,714	20
	2020	300	0.33	0.78	$1,551	20
	2025	300	0.33	0.78	$1,343	20
	2030	300	0.34	0.79	$1,134	20
Oil-Fired Engine	2005	200	0.31	0.72	$1,320	20
	2010	200	0.31	0.72	$1,150	20
	2015	200	0.31	0.71	$1.04	20
	2020	200	0.31	0.71	$990	20
	2025	200	0.31	0.71	$990	20
	2030	200	0.31	0.71	$990	20
Natural Gas Turbine	2005	1000	0.22	0.68	$2,000	20
	2010	1000	0.23	0.68	$1,775	20
	2015	1000	0.24	0.68	$1,684	20
	2020	1000	0.24	0.69	$1,593	20
	2025	1000	0.25	0.69	$1,511	20
	2030	1000	0.26	0.7	$1,429	20
Natural Gas Micro-Turbine	2005	200	0.29	0.6	$1,706	20
	2010	200	0.29	0.6	$1,648	20
	2015	200	0.31	0.61	$1,633	20
	2020	200	0.33	0.61	$1,573	20
	2025	200	0.34	0.62	$1,343	20
	2030	200	0.36	0.63	$1,052	20

Sources: Energy Information Administration, Commercial and Industrial CHP Technology Cost and Performance Data Analysis for EIA's NEMS,

Decision Analysis Corporation and Discovery Insights LLC., February 2006, National Renewable Energy Laboratory, Gas-Fired Distributed Energy Resource Technology Characterizations: Reference Number NREL/TP-620-34783, November 2003, Discovery Insights, LLC, "Installed Costs for Small CHP Systems - Estimates and Projections" (April 2005), and Solar Energy Industries Association, Our Solar Power Future - The U.S. Photovoltaic Industry Roadmap through 2030 and Beyond, (SEIA, September 2004).

Industrial Sector data from p. 54 of source

Table 22. Cost Characteristics of Industrial CHP Systems

Type	Size (kilowatts)	Installed Cost ($2005 per kilowatt)[1] 2005	2030
1 Engine	1000	1,194	860
2 Engine	3000	947	808
3 Gas Turbine	3000	1,330	1,100
4 Gas Turbine	5000	1,026	851
5 Gas Turbine	10000	960	834
6 Gas Turbine	25000	809	707
7 Gas Turbine	40000	700	646
8 Combined Cycle	100000	736	684

Source: Energy Information Administration, Model Documentation Report: Industrial Sector Demand Module of the National Energy Modeling System, DOE/EIA-MO64(2007) (Washington, DC, 2007).

Estimate of Mitigation Option Costs and Benefits for North Carolina RCI GHG Analysis

RCI-11 **Residential, Commercial, and Industrial Energy and Emissions Technical Assistance and Recommended Measure Implementation**

Date Last Modified: 5/31/2007 D. Von Hippel/A Bailie

Key Data and Assumptions	2010	2020/all	Units
First Year Results Accrue		2008	
Levelized Cost of Electricity Savings from Technical Assistance Recommendations		$33	$/MWh
Residential Sector		$31	$/MWh
Commercial Sector		$46	$/MWh
Industrial Sector		$20	$/MWh

Estimated based on savings included in the GDS Report for the NC Utilities Commission, A Study of the Feasibility of Energy Efficiency as an Eligible Resource as Part of a Renewable Portfolio Standard for the State of North Carolina, dated 12/2006. See Note 1. The averages from the GDS report are based on a discount rate of 10 percent nominal, and have been approximately adjusted using a real discount rate of 5%/yr to yield the values above. See "GDS calcs" worksheet in this workbook. Estimates ulitimately used should present total costs including both costs of the technical assistance visits themselves and the costs (incremental equipment costs net of non-energy savings) of the measures implemented. As the GDS estimates do include program administration and marketing costs, at least some of the costs of technical assistance visits can reasonably be assumed to be included in these values.

Levelized Cost of Natural Gas and Other Fuels Savings		$2.1	$/MMBtu
Residential Sector		$2.1	$/MMBtu
Commercial Sector		$2.1	$/MMBtu
Industrial Sector		$2.1	$/MMBtu

Based on an average for Gas DSM programs as used in evaluation of RCI-2, and derived from data in Tegen, S. and Geller, H., 2006. Natural Gas Demand-Side Management Programs: A National Survey, Southwest Energy Efficiency Project, www.swenergy.org. Should be replaced with sector- and/or NC-specific estimates when available.

Avoided Electricity Cost		$57	$/MWh

Weighted average over total 2006-2010 electricity savings for this policy in each sector.

Avoided Natural Gas Cost		$8.0	$/MMBtu
Avoided LPG Cost		$12.3	$/MMBtu
Avoided Oil Cost		$13.4	$/MMBtu
Annual Technical Assistance Visits: Residential Sector		10,000	
Annual Technical Assistance Visits: Commercial Sector		1,500	
Annual Technical Assistance Visits: Industrial Sector		300	
Total (all Sectors) Technical Assistance Visits Over Life of Program		153,400	

Other Data, Assumptions, Calculations	2010	2020/all	Units

Inputs to/Intermediate Results of Calculation of Electricity and Gas Savings

Residential Sector

Average energy consumption per household

Electricity	13.6	13.8	MWh
Natural Gas	18.0	18.3	MMBtu
LPG	7.2	7.3	MMBtu
Oil (Kerosene and Distillate Oil)	7.6	7.0	MMBtu

Average Savings from Application of Measures from Technical Assistance Visits

Electricity	20%
Other Fuels	20%
Average Fraction of Participants Installing Measures Following Visits	75%

Values above are rough estimates based on an aggressive program with significant incentives available. Average savings, however, are well within the range of those found (for example) in Greenville (NC) Utilities' longstanding (since 1977) residential survey/audit program, which frequently identifies savings potential for residential customers of up to 50 percent in overall energy use. Savings found commonly include building envelope and heating/cooling system measures, but also hot water system measures including simple plumbing fixes (personal correspondence with Andy Yakim of Greenville Utilities, 5/25/07).

Estimated Savings From Application of Measures (first-year savings, not cumulative)

Electricity	20.3	20.7	GWh
Natural Gas	27.0	27.4	Billion Btu
LPG	10.8	11.0	Billion Btu
Oil (Kerosene and Distillate Oil)	11.4	10.5	Billion Btu

Commercial Sector

Estimated Commercial-sector (Electricity) Customers

Based on estimate of future commercial square feet presented in RCI-3 (currently based on NC population growth).

Average energy consumption per commercial (electricity) customer

Electricity	77.1	89.5	MWh
Natural Gas	76.5	74.7	MMBtu
LPG	7.6	7.7	MMBtu
Oil (Kerosene and Distillate Oil)	24.7	20.3	MMBtu
Average Fraction of Participants Installing Measures Following Visits		75%	

Average Savings from Application of Measures from Technical Assistance Visits

Electricity	20%
Other Fuels	20%
Average Fraction of Participants Installing Measures Following Visits	65%

Average savings estimate is similar to average potential savings found in relatively extensive commercial-sector energy technical assistance programs. Achieved savings assumes provision of an aggressive program of services, and the availability of significant incentives to encourage participating consumers to adopt audit recommendations. By way of comparison, an technical assistance program for commercial and industrial customers carried out by Waste Reduction Partners (WRP) in Western North Carolina found potential energy savings from visits carried out in 2006 equal to 8.8 percent of total utility bills in businesses and institutions participating. The WRP program is staffed largely by volunteer retired engineers, and provides limited "energy audit" services (Terry Albrecht of WRP, personal communication). The fraction of participants assumed to install measures following visits reflects a combination of an aggressive program and the availability of substantial customer incentives, for example, from utility DSM programs, energy efficiency funds, or government lead-by-example programs.

Estimated Savings From Application of Measures (first-year savings, not cumulative)

Electricity	15.0	17.5	GWh
Natural Gas	14.9	14.6	Billion Btu
LPG	1.5	1.5	Billion Btu
Oil (Kerosene and Distillate Oil)	4.8	4.0	Billion Btu

Industrial Sector

Estimated Industrial-sector (Electricity) Customers

Average annual growth rate in customer numbers	**-1.5%**

Initial estimate--1999 to 2005 rate of change in industrial electricity customer numbers was -2.5%.

Average energy consumption per industrial (electricity) customer

Electricity	**2,925.2**	**3,384.8**	MWh
Natural Gas	**2,362.8**	**2,717.8**	MMBtu
LPG	**2,627.3**	**3,385.3**	MMBtu
Oil (Kerosene and Distillate Oil)	**2,470.5**	**2,993.4**	MMBtu

Average Savings from Application of Measures from Technical Assistance Visits

Electricity	**20%**
Other Fuels	**20%**
Average Fraction of Participants Installing Measures Following Visits	**75%**

Average savings estimate is similar to average potential savings found in relatively extensive industrial-sector energy technical assistance programs. Achieved savings and fraction of customers installing measures assumes provision of an aggressive program of services, and the availability of significant incentives to encourage participating consumers to adopt technical assistance recommendations.

Estimated Savings From Application of Measures (first-year savings, not cumulative)

Electricity	**131.6**	**152.3**	GWh
Natural Gas	**106.3**	**122.3**	Billion Btu
LPG	**118.2**	**152.3**	Billion Btu
Oil (Kerosene and Distillate Oil)	**111.2**	**134.7**	Billion Btu

Results	2010	2020	Units
Electricity Savings			
Reduction in Electricity Sales: Residential	61	267	GWh (sales)
Reduction in Electricity Sales: Commercial	45	208	GWh (sales)
Reduction in Electricity Sales: Industrial	389	1,813	GWh (sales)
TOTAL Reduction in Electricity Sales	495	2,288	GWh (sales)
Reduction in Generation Requirements	527	2,424	GWh (generation)
GHG Emission Savings	**0.46**	**1.73**	$MMtCO_2e$
Economic Analysis			
Net Present Value (2007-2020)		**-$316**	$million
Cumulative Emissions Reductions (2007-2020)		12.9	$MMtCO_2e$
Cost-Effectiveness		**-$24.52**	$/tCO_2e$
Natural Gas and Other Fuel Savings			
Reduction in Natural Gas Use: Residential	54	326	Billion BTU
Reduction in Natural Gas Use: Commercial	30	178	Billion BTU
Reduction in Natural Gas Use: Industrial	208	1,339	Billion BTU
TOTAL Reduction in Natural Gas Sales	**291**	**1,843**	Billion BTU
Reduction in LPG Use: Residential	22	131	Billion BTU
Reduction in LPG Use: Commercial	3	18	Billion BTU
Reduction in LPG Use: Industrial	228	1,562	Billion BTU
TOTAL Reduction in LPG Sales	**252**	**1,711**	Billion BTU
Reduction in Oil Use: Residential	23	133	Billion BTU
Reduction in Oil Use: Commercial	10	54	Billion BTU
Reduction in Oil Use: Industrial	216	1,429	Billion BTU
TOTAL Reduction in Oil Sales	**249**	**1,616**	Billion BTU
GHG Emission Savings	**0.05**	**0.32**	$MMtCO_2e$
Economic Analysis			
Net Present Value (2007-2020)		**-$179**	$million
Cumulative Emissions Reductions (2007-2020)		2.0	$MMtCO_2e$
Cost-Effectiveness		**-$87.34**	$/tCO_2e$

Summary Results for RCI-11	2010	2020	Units
Total for Policy (Electricity, Natural Gas and Other Fuels)			
GHG Emission Savings	**0.51**	**2.05**	$MMtCO_2e$
Net Present Value (2007-2020)		**-$494**	$million
Cumulative Emissions Reductions (2007-2020)		14.9	$MMtCO_2e$
Cost-Effectiveness		**-$33.13**	$/tCO_2e$

NOTES AND DATA FROM SOURCES

Note 1:

From The Energy Efficiency Task Force Report to the Clean and Diversified Energy Advisory Committee of the Western Governors Association.
The Potential for More Efficient Electricity Use in the Western United States, January, 2006. This report is referred to here as the "WGA CDEAC EE report" and can be found at: http://www.westgov.org/wga/initiatives/cdeac/Energy%20Efficiency-full.pdf.

Estimate of Mitigation Option Costs and Benefits for North Carolina RCI GHG Analysis

Calculations based on Energy Efficiency Report by GDS Associates for NC Utilities Commission

Date Last Modified:	*2/12/2007*	*D. Von Hippel/A Bailie*

From A Study of the Feasibility of Energy Efficiency as an Eligible Resource as Part of a Renewable Portfolio Standard for the State of North Carolina. Dated 12/1/2006.
Report for the North Carolina Utilities Commission,
prepared and submitted by: GDS Associates, Inc.
Referred to below as the "GDS Report".

From page 10:
Table 1-5: Calculation of Cost per Lifetime kWh Saved by Sector for the RPS Energy Efficiency Scenario

	Present Value of Total Costs (2006 $)	Value of Lifetime kWh Savings - Customer Meter Level	Levelized Cost per Lifetime kWh Saved
Residential Sector	$262,528,658	9,673,701,174	$0.027
Commercial Sector	$352,185,339	8,702,321,930	$0.040
Industrial Sector	$124,388,270	6,805,459,342	$0.018
Total - All Sectors	$739,102,267	25,181,482,446	$0.029

For this RPS study for North Carolina, the initial levelized cost per lifetime kWh saved for each energy efficiency measure was calculated by calculating an annual installment loan payment to represent the annualized cost of the measure cost over its useful life, and then dividing this annualized cost by the first year kWh savings of the measure. This levelized cost per lifetime kWh saved for each energy efficiency measure can then be compared to the levelized cost of electric generation in North Carolina (including capital and operating costs). The levelized cost calculations shown in Table 1-5 include all costs, including program administration and financial incentives

The estimated cost, using CCS parameters is **$33.0** 2005$/lifetime MWh
for the All Sectors weighted average levelized cost of energy savings. Making a proportional adjustement for individual sectors yields the following approximate adjusted costs for energy energy efficiency investments in each individual sector:

	Levelized Cost per Lifetime kWh Saved Adjusted for CCS Parameters
Residential Sector	$0.031
Commercial Sector	$0.046
Industrial Sector	$0.020

CCS calculations
Adjustments needed:
ensure total cost includes all customer costs
discount rates, GDS uses 10% (not sure if this is nominal), CCS uses 5% real
ensure total cost includes all customer costs
change from 2006$ to 2005$

Discount rate
adjust total costs to reflect CCS parameters for discount rate

GDS parameters	**10.0%**	nominal -- (as indicated at the bottom of table 1-4 of GDS Report)
	2.5%	annual inflation rate
	5.6%	Estimated annual line losses between the customer meter and the electric generation plant (page 147 of GDS Report)
CCS Parameter	**5.0%**	real discount rate

Adjusted Total Discounted Costs (2005$) $831,297,957
Adjusted total calculated from values in Table 1-4 of GDS report--see below.

Adjusted cost of saved energy

lifetime energy savings

25,181,482,446	kWh (Note that this appears to be a discounted value, possibly including end effects (post-2027 savings). If it is a discounted value, the cost per lifetime kWh savings calculated below may be overstated, since GDS likely used a higher discount rate than 5 percent real to estimate discounted kWh savings.)
$0.033	in 2005$ per lifetime kWh
$33.012	2005$/MWh

Estimated Program Administrator Costs with Financial Incentives, 2005 dollars per unit first-year savings

101.67	2005$/MWh in 2008, and
96.77	2005$/MWh in 2015

From page 9:

Table 1-4: Costs and Savings for the RPS 10% Scenario With Energy Efficiency Included

Year	Total Cumulative Annual GWh Saved From Energy Efficiency Programs - Generation Level	Total GW Savings - Generation Level	Total Energy Efficiency Costs (Nominal Dollars) = Sum of All Costs (Program Administration, Program Administator Measure Costs, Participant Measure Costs)	Total Program Administrator Costs with financial incentives (Included in Total Energy Efficiency Costs - Excludes Participant Costs)	Administrator Costs just for administration, marketing, data tracking and reporting (Included in Total Energy Efficiency Costs; Equal to $.02 per first year kWh saved	Total Measure Costs (excludes administative costs for staffing, marketing, etc.)
2008	384.688	0.078	$81,399,026	$44,475,130	$7,551,234	$73,847,792
2009	782.226	0.159	$83,938,942	$45,954,749	$7,970,555	$75,968,387
2010	1,195.27	0.243	$86,863,664	$47,653,502	$8,443,341	$78,420,323
2011	1,622.89	0.33	$89,864,660	$49,402,677	$8,940,694	$80,923,966
2012	2,067.22	0.42	$93,199,962	$51,345,432	$9,490,902	$83,709,060
2013	2,524.07	0.513	$95,725,573	$52,849,259	$9,972,946	$85,752,628
2014	2,995.40	0.609	$98,778,887	$54,654,475	$10,530,063	$88,248,823
2015	3,479.42	0.707	$102,593,157	$56,775,798	$10,958,439	$91,634,718
2016	3,989.11	0.811	$108,406,553	$60,137,107	$11,867,662	$96,538,891
2017	4,509.67	0.917	$111,822,115	$62,095,625	$12,369,135	$99,452,980
2018	4,510.85	0.917	$44,217,241	$24,667,899	$5,118,557	$39,098,683
2019	4,510.35	0.917	$64,218,701	$35,907,753	$7,596,805	$56,621,896
2020	4,509.75	0.917	$67,529,384	$37,846,627	$8,163,869	$59,365,516
2021	4,510.92	0.917	$72,165,999	$40,540,695	$8,915,391	$63,250,608
2022	4,510.39	0.917	$76,629,257	$43,151,334	$9,673,411	$66,955,846
2023	4,510.22	0.917	$79,401,221	$44,821,353	$10,241,485	$69,159,736
2024	4,510.38	0.917	$82,447,065	$46,656,061	$10,865,058	$71,582,007
2025	4,510.77	0.917	$83,505,450	$47,296,580	$11,087,710	$72,417,740
2026	4,509.82	0.917	$89,232,277	$50,637,817	$12,043,356	$77,188,921
2027	4,509.98	0.917	$90,687,965	$51,540,110	$12,392,254	$78,295,711
Present Value in 2006 $ [from GDS Report]*			$739,102,267	$409,135,707	$79,169,146	$659,933,121

*Based on a discount rate of 10%

Following are recalculations of present values and unit costs from GDS report, Table 1-4, approximately consistent with treatment of costs by CCS elsewhere in this workbook.

			Costs in real year 2005 Dollars			
Year	Total Cumulative Annual GWh Saved From Energy Efficiency Programs - Generation Level	Total GW Savings - Generation Level	Total Energy Efficiency Costs (Nominal Dollars) = Sum of All Costs (Program Administration, Program Administator Measure Costs, Participant Measure Costs)	Total Program Administrator Costs with financial incentives (Included in Total Energy Efficiency Costs - Excludes Participant Costs)	Administrator Costs just for administration, marketing, data tracking and reporting (Included in Total Energy Efficiency Costs; Equal to $.02 per first year kWh saved	Total Measure Costs (excludes administative costs for staffing, marketing, etc.)
2008	384.69	0.078	$ 75,587,088	$ 41,299,580	$ 7,012,071	$ 68,575,016
2009	782.23	0.159	$ 76,044,539	$ 41,632,734	$ 7,220,929	$ 68,823,609
2010	1,195.27	0.243	$ 76,774,822	$ 42,118,752	$ 7,462,683	$ 69,312,139
2011	1,622.89	0.33	$ 77,490,015	$ 42,599,774	$ 7,709,532	$ 69,780,482
2012	2,067.22	0.42	$ 78,405,888	$ 43,195,127	$ 7,984,366	$ 70,421,522
2013	2,524.07	0.513	$ 78,566,436	$ 43,375,848	$ 8,185,261	$ 70,381,175
2014	2,995.40	0.609	$ 79,095,056	$ 43,763,388	$ 8,431,720	$ 70,663,335
2015	3,479.42	0.707	$ 80,145,610	$ 44,353,163	$ 8,560,715	$ 71,584,895
2016	3,989.11	0.811	$ 82,621,489	$ 45,833,182	$ 9,044,877	$ 73,576,612
2017	4,509.67	0.917	$ 83,145,992	$ 46,171,567	$ 9,197,143	$ 73,948,849
2018	4,510.85	0.917	$ 32,076,088	$ 17,894,597	$ 3,713,106	$ 28,362,981
2019	4,510.35	0.917	$ 45,449,321	$ 25,412,893	$ 5,376,465	$ 40,072,856
2020	4,509.75	0.917	$ 46,626,714	$ 26,131,792	$ 5,636,870	$ 40,989,844
2021	4,510.92	0.917	$ 48,612,816	$ 27,309,223	$ 6,005,630	$ 42,607,187
2022	4,510.39	0.917	$ 50,360,369	$ 28,358,843	$ 6,357,318	$ 44,003,051
2023	4,510.22	0.917	$ 50,909,356	$ 28,737,924	$ 6,566,491	$ 44,342,865
2024	4,510.38	0.917	$ 51,572,924	$ 29,184,659	$ 6,796,395	$ 44,776,529
2025	4,510.77	0.917	$ 50,960,950	$ 28,863,728	$ 6,766,507	$ 44,194,442
2026	4,509.82	0.917	$ 53,127,674	$ 30,149,062	$ 7,170,449	$ 45,957,225
2027	4,509.98	0.917	$ 52,677,435	$ 29,937,829	$ 7,198,223	$ 45,479,212
Undiscounted Total			$ 1,270,250,580	$ 706,323,666	$ 142,396,752	$ 1,127,853,828
Present Value in 2005 $ (using 5% real discount rate)			$831,297,957	$460,761,472	$90,224,989	$741,072,968
Implied cost per MWh savings, $2005			$ 33.01			

Estimate of Mitigation Option Costs and Benefits for North Carolina RCI GHG Analysis

Background data on Green Power cost from "La Capra" Report

Date Last Modified:	*2/12/2007*	*D. Von Hippel/A Bailie*

Tables and Figures below are from ANALYSIS OF A RENEWABLE PORTFOLIO STANDARD FOR THE STATE OF NORTH CAROLINA, TECHNICAL REPORT, prepared by La Capra Associates for the North Carolina Utilities Commission, and dated December, 2006. Document available as http://www.ncuc.commerce.state.nc.us/rps/NC%20RPS%20Report%2012-06.pdf

We use figures from this report to estimate future net "Green Power" costs for use in RCI-9. Based on 10-year NPV data for the RPS Scenario "II. Expanded" to provide a 10 percent RPS by 2017, an average value for the net cost of RPS power per unit of renewable electricity generated is estimated as below:

Estimated sum of 10-year generation requirement above (read from Figure 5): 47,100 GWh

10-year net NPV of RPS (10% by 2017, scenario II) as indicated in Table 4, above:

$787 million

Implied average levelized net cost per MWh of RPS generation at 10% level, no EE

$16.71 /MWh

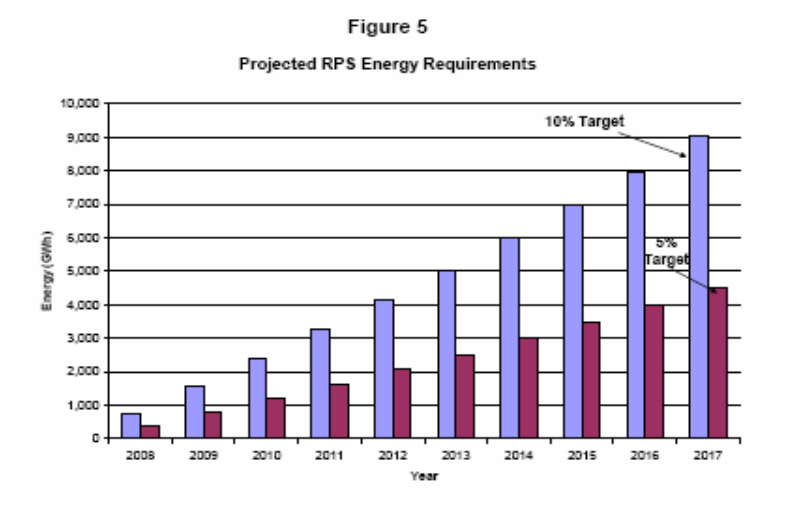


Table 14: Total Incremental Cost Over 10 Years in NPV

RPS Scenario	Resources	10-year NPV ($million) Utility Portfolio	Alternate Portfolio	Net Incremental Cost (with Marginal Energy)
5% by 2017	I. NCGP	$7,028	$7,646	$375
	II. Expanded		$7,484	$204
	III. Plus Energy Efficiency		$7,024	($95)
10% by 2017	I. NCGP		$8,983	$1,381
	II. Expanded		$8,281	$787
	III. Plus Energy Efficiency		$6,973	($177)

Appendix F
Energy Supply
Mitigation Option Recommendations

Summary List of Mitigation Option Recommendations

Option No.	Mitigation Option Name	GHG Reductions ($MMtCO_2e$)			Net Present Value (Million $)	Cost-Effective-ness ($/$tCO_2e$)	Level of Support
		2010	2020	Total 2007–2020			
ES-1	Renewable Energy Incentives	0.01	0.04	0.33	15	45.1	UC
ES-2	Environmental Portfolio Standard						
ES-2a	*Original Analysis*	6.94	44.3	288.7	1,634	5.7	UC
ES-2b	*20% Combined Target*	5.90	23.4	166.2	409.80	2.5	UC
ES-2c	*Load Growth Offset Target*	5.53	22.3	160.3	393.95	2.5	UC
ES-3	Removing Barriers to CHP and Clean DG	0.69	2.8	20.1	127.98	6.4	UC
ES-4	CO_2 tax and/or Cap-and-Trade						
ES-4a	*Electricity Sector Only*	0.84	3.3	20.4	119	5.8	SMJ
ES-4b	*Economy-wide*	1.84	7.1	47.7	284	6.0	SMJ
ES-5	Legislative Changes to Address Environmental and Other Factors	*Not quantified*					UC
ES-6	Incentives for Advanced Coal						
ES-6a	*Replacement of New 800-MW Pulverized Coal Plant*	0.00	3.9	31.0	949	30.6	UC
ES-6b	*Replacement of Existing 800-MW Pulverized Coal plant*	0.00	5.4	42.9	2,061	48.1	UC
ES-7	Public Benefit Charge	0.8	3.4	24.4	329	13.5	SMJ
ES-8	Waste-to-Energy	0.0	0.0	0.02	–0.7	–36.8	UC
ES-9	Incentives for CHP and Clean DG	*Combined with ES–3*					UC
ES-10	NC GreenPower Renewable Resources Program	0.01	0.2	0.95	35	37.0	UC
	SECTOR TOTAL AFTER ADJUSTING FOR OVERLAPS*	6.5	62.7	375	–5.9	–0.016	
	REDUCTIONS FROM RECENT ACTIONS (none)	0	0	0	0	0	
	SECTOR TOTAL PLUS RECENT ACTIONS*	6.5	62.7	375	–5.9	–0.016	

UC = unanimous consent (all agree); SMJ = supermajority (at least 80% or more agree).

* For ES-2, ES-4, and ES-6, emission reductions and costs associated with ES-2b, ES-4a, and ES 6a were used in the cumulative analysis.

ES-1. Renewable Energy Incentives (Biomass, Wind, Solar, Geothermal, Hydro)

Mitigation Option Description

This option focuses on financial incentives that promote the greater use of renewable energy. They are focused primarily for residents, businesses, and other end-users rather than for research and development, outreach, or inter-governmental programs. The effect of these incentives is to encourage investment in renewables by providing direct financial support.

Mitigation Option Design

Goals: Subsidy to renewable energy generators at $0.005 per kilowatt-hour (c/kWh) for each kWh of electricity generated from a qualifying renewable facility.

Timing: Tie into the timing of actions taken as a result of the North Carolina Utilities Commission (NCUC) Renewable Portfolio Standard (RPS) study. As a default, implement payments starting in 2008, and continuing through 2020.

Coverage of Parties: All power producers operating qualifying renewable facilities in North Carolina would receive the direct payments.

Other: Not applicable.

Implementation Mechanisms

The proposed implementation mechanism for this option is the direct payment mechanism. These represent direct subsidies for purchasing or selling renewable technologies given to the buyer or seller. Other possible implementation mechanisms include (a) tax credits or exemptions for purchasing or selling renewable technologies given to the buyer or seller, (b) tax credits or exemptions for operating renewable energy facilities, (c) feed-in tariffs which provide direct payments to renewable generators for each kWh of electricity generated from a qualifying renewable facility, and d) tax credits for each kWh generated from a qualifying renewable facility.

Related Policies/Programs in Place

NC GreenPower.

Type(s) of GHG Reductions

Renewable generation can reduce fossil fuel use in power generation and correspondingly reducing carbon dioxide (CO_2) emissions. To the extent that generation from coal and oil is displaced by renewables, black carbon emissions will decrease.

Estimated GHG Savings and Costs per $MtCO_2e$

The table below summarizes the annual GHG reductions in 2010 and 2020, the cumulative greenhouse gas (GHG) reductions through 2020, the incremental cost of the option (expressed in

net present value terms), and the cost-effectiveness of the option (expressed in terms of dollars per metric ton of carbon dioxide equivalent [$/t$CO_2$e] avoided).

Option No.	Option Name	GHG Reductions ($MMtCO_2e$)			NPV of Costs (million 2005$)	Cost of Saved Carbon (2005$/t$CO_2$e avoided)
		2010	2020	Total (2007–2020)		
ES-1	Incentives for centralized renewables	0.01	0.04	0.33	$15	$45.1

NPV = net present value

Data Sources: The Energy Information Agency's (EIA's) Annual Energy Outlook (AEO) for 2006; "Clean Energy Technologies: A Preliminary Inventory of the Potential for Electricity Generation" by Owen Bailey and Ernst Worrell, LBNL-57451, April 2005.

Quantification Methods: Ideally, one would undertake a full economic modeling exercise to assess the least cost mix/level of renewable energy, relative to North Carolina resource constraints and the incentives proposed. However, such an exercise would be both time-consuming and subject to very large uncertainties. Given time and budget limitations, an alternative analysis strategy was used that aimed to use previous analysis within a transparent spreadsheet structure. Hence, the completed analysis used a simple spreadsheet tool to assess the impact that financial incentives for centralized renewables would have on the penetration of renewable energy. The initial results of the RPS study under preparation in North Carolina will be reviewed for insights into a suitable renewable technology mix in the final of this report. The analysis involves the following steps:

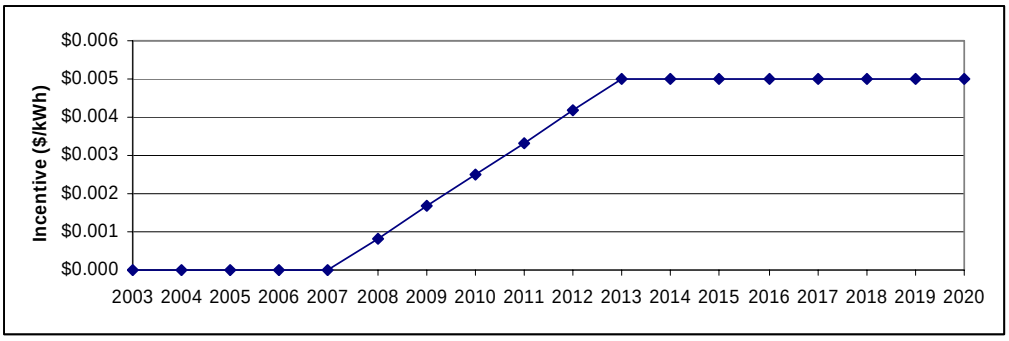
- Identify the type of renewable generation that would most likely be developed as a result of the Environmental Portfolio Standard (EPS) case combined with the financial incentives using a cost curve approach and taking into account renewable energy resources in North Carolina as noted in the LaCapra study and the fact that the RPS bill has passed;
- Estimate the incremental costs associated with each type of renewable technology on a societal costs basis;
- Estimate the incremental renewable generation resulting from the incentive on the basis of a comparison of the net program costs with and without the payments associated with the tax incentives.
- Estimate the amount of CO_2 emissions that are expected to be avoided by the additional renewables resulting from the renewable energy incentives relative to the Reference Case.

Key Assumptions: Where applicable, the key assumptions were the same as those used in analyzing the EPS. It is assumed that the renewables mix developed for the EPS was modified such that the renewables mix may be different relative to cost the competitiveness of these resources after the subsidies.

Analytical Issues: There were several assumptions that were made in quantifying the GHG reduction benefits and cost-effectiveness of this option, as follows:

- *Amount of incentive:* Per guidance from the Climate Action Plan Advisory Group (CAPAG), the maximum level of the incentive was set at 0.5 c/kWh and was phased in according to the schedule shown in Figure F-1.

Figure F-1. Proposed renewable energy incentive phase-in: 2007–2020



- *Renewable energy mix:* Per guidance from the Technical Work Group (TWG) during the December 19 meeting, the recently completed RPS study[1] for the Public Utilities Commission was reviewed for renewable resource potential in North Carolina and compared with other sources. Resource potential in North Carolina from this study is summarized in Table F-1.

Table F-1. Estimated renewable energy potential in North Carolina

Resource	Generation (GWh)		Share of total generation (%)	
	Maximum	Practical	Maximum	Practical
Conventional hydropower	2,032	1,700	3%	11%
Geothermal	0	0	0%	0%
Hog waste	748	600	1%	4%
Co-firing	12,207	2,500	20%	17%
Dedicated biomass	20,661	6,200	34%	42%
Solar thermal	0	0	0%	0%
Solar photovoltaic	0	0	0%	0%
Wind (onshore)	24,960	3,900	41%	26%
Total	**60,608**	**14,900**	**100%**	**100%**

Note: shares of total generation are calculated relative to each estimate, whether maximum or practical. For example, the hydroelectric "practical" potential is 1,700 GWh (gigawatt-hours), or 11% of the total practical potential.

The resource shares in Table F-1 are considerably different from Energy Information Agency (EIA) estimates, which show mostly wind (81%) and the rest consisting of municipal waste (19%). Hence, the analysis was set up to consider three sensitivities, as follows:

[1] LaCapra Associates, 2006, *Analysis of a Renewable Portfolio Standard for the State of North Carolina*, December.

1. LaCapra "practical": This corresponds to the practical assumptions in the RPS report. **Note that this was the default assumption.**

2. LaCapra "technical potential": This corresponds to the maximum assumptions in the RPS report.

3. EIA estimates for the Southeastern Electric Reliability Council (SERC): This corresponds to the EIA assumptions.

- *Levelized costs:* Levelized cost assumptions in 2020 are provided in Table F-2 for low, midrange, and high values.

Table F-2. Estimated levelized costs* of renewables (2005 $/MWh [megawatt-hour])

Resource	Low	Mid-range (default)	High
Hydro	91.5	102	113.0
Wind	55.0	80	105.0
Solar photovoltaics (PV)	185.7	255	325.0
Hog waste	73.4	73	73.4
Poultry litter	73.4	73	73.4
Biomass co-firing in coal plants	4.5	12	19.9
Dedicated biomass combustion	82.6	99	115.1

*Constant level of annual revenue needed to recover all expenses over the life of a power-generating facility.

- *Avoided costs:* The Residential, Commercial, and Industrial (RCI) TWG calculated the avoided costs associated with electricity sector expansion. Avoided costs were calculated starting with the levelized 15-year avoided costs from Duke Power, Progress Energy, and Dominion Resource Services price schedules for qualifying facilities purchased power, as filed in late 2005 with the NCUC (Docket No. E-100, Sub 100). Weighted average annual avoided costs were developed by application of estimated weighting factors for on-peak and off-peak usage, and for the fraction of North Carolina's electricity supplied by each of the three utilities. The implied utility-weighted average avoided cost was computed to be $57/MWh.
- *Marginal impact of renewable generation:* The introduction of new renewable generation associated with the incentive is assumed to displace generation from existing and/or new facilities. The analysis assumes that 50% of the generation displaced by the new renewable generation would be coal-fired and the balance natural gas-fired.

New renewable generation: It was assumed that the level of new renewable generation would be constrained, given the low level of the incentive. It was further assumed that the level of new generation would be less than the renewable generation levels in the Reference Case. The graphs in Figures F-2a and F-2b show the total incremental renewable generation assumed to come on line by the incentives between 2003 and 2020, as well as the new renewable generation mix in 2020.

Figure F-2a. Estimated renewable generation increase due to incentives

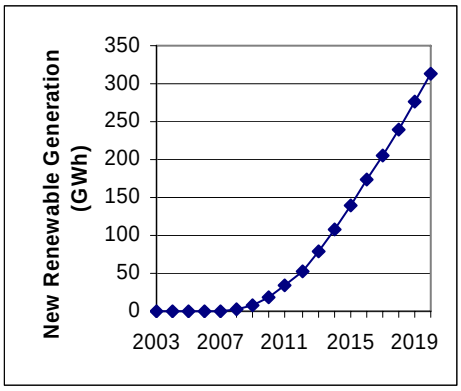
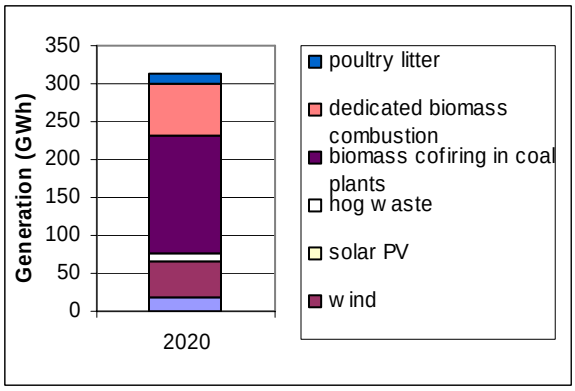


Figure F-2b. Projected mix of renewable generation: 2020



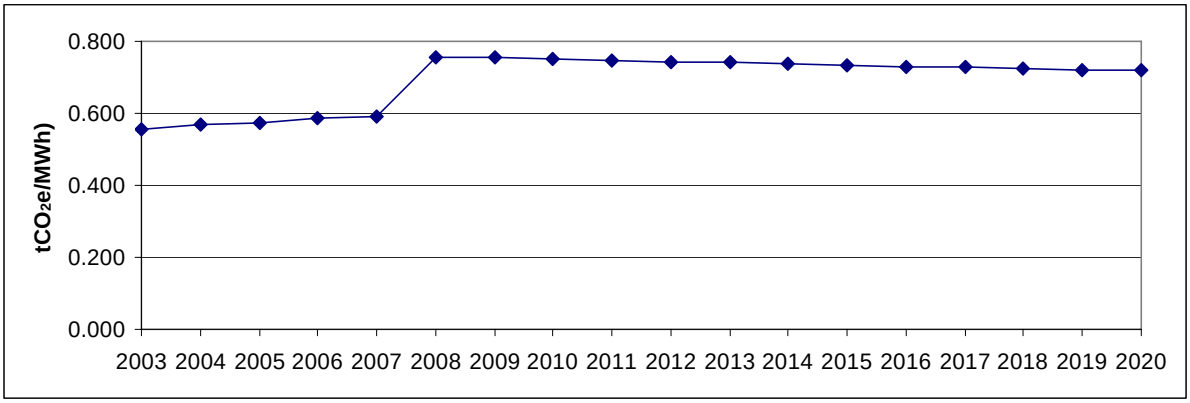
System CO_2e emission factor: The introduction of new renewable generation will lead to different reductions of greenhouse gases (GHGs) depending upon whether the full fuel cycle is considered, or whether only GHG emissions are considered at the point of generation. Since it was unclear how the TWG would opt to proceed, the analysis was set up to consider two sensitivities, as follows:

1. Full fuel cycle emissions associated with electricity supply. This assumes that upstream stages of the full fuel cycle (e.g., extraction, transport, or beneficiation) are considered the development of CO_2e emission factors. **Note that this is the default assumption and the results reflect this assumption.**

2. Emissions associated with electricity generation only. This assumes that only the generation stage of the fuel cycle is considered the development of CO_2e emission factors.

Generation-specific average system emission factors were determined based on information developed in the NC Inventory and Forecast analysis. Full fuel cycle emission factors were determined based on U.S. Department of Energy (US DOE) sources for upstream emissions. Figure F-3 shows the average emission factor associated with the generation displaced by new renewable generation.

Figure F-3. Average emission factor associated with generation displaced by new renewable generation



Long-term costs: The net present value costs of the incentives for each technology over the 2008–2020 period is summarized in Table F-3. These costs represent the level of the subsidy needed to achieve the associated generation.

Table F-3. Costs of renewables incentives: 2008–2020

Resource	NPV (million 2005$)
Hydro	$2.7
Wind	$5.7
Solar PV	$0.8
Biomass and waste	$11.9
Hog waste	$0.4
Poultry litter	$0.6
Biomass co-firing in coal plants	$0.9
Dedicated biomass combustion	$10.0
Total	**$21.2**

NPV = net present value

- *Ancillary benefits:* There are a number of incentives that are worth noting. First, reductions in overall energy consumption and the shift from fossil fuel generation as a result of the incentives would lead to reductions in criteria air pollutants and, consequently, health costs associated with those pollutants. Second, the renewable generation promoted by the incentives, though small in magnitude, could nevertheless provide a fuel price hedge effect against fossil fuel price volatility, particularly natural gas in North Carolina. Finally, the operating costs of renewable generation, primarily maintenance, are generally spent locally and can provide a direct boost to local economies.

Rate impacts: A number of sensitivities were conducted to explore rate impacts associated with this mitigation option. Rate impacts were calculated in a three-step process as follows:

1. Determine displacement of fossil generation by energy efficiency and/or renewable generation,

2. Determine the incremental cost associated with this displacement; and

3. Calculate the rate impact by dividing the annual cost impact by total resulting retail electricity sales in North Carolina.

A summary of rate impacts for each of the sensitivities is summarized in Table F-4.

Table F-4. Summary of rate impacts for six sensitivities

		GHG Reductions ($MMtCO_2e$)					2020 Rate Impact (2005 c/kWh)		
	Option Name	2010	2020	Total 2007–2020	NPV of Costs (million 2005$)	Cost of Saved Carbon (2005$/$tCO_2e$ avoided)	Energy Effi-ciency	Renew-able Energy	Total
ES-1	Incentives for centralized renewables								
1	Original analysis (default assumptions)	0.01	0.04	0.33	$15	$45.1		0.0014	0.00143
2	Original analysis–low levelized cost estimate	0.02	0.08	0.68	–$18	–$26.1		0.0014	0.00143
3	Original analysis–high levelized cost estimate	0.01	0.03	0.23	$25	$108.3		0.0014	0.00143
4	Original analysis–central levelized cost estimate (2% solar PV set-aside)	0.01	0.04	0.32	$15	$47.9		0.0014	0.00143
5	Original analysis–low levelized cost estimate (2% solar PV set-aside)	0.02	0.08	0.67	–$17	–$24.7		0.0014	0.00143
6	Original analysis–high levelized cost estimate (2% solar PV set-aside)	0.01	0.03	0.23	$26	$112.4		0.0014	0.00143

2005 c/kWh = cents per kilowatt hour in 2005 dollars; NPV = net present value

Key Uncertainties

- North Carolina–specific costs of energy supply technologies modeled.
- Marginal impact of additional renewable generation on system dispatch in North Carolina.

Additional Benefits and Costs

Introducing additional renewable generation also reduces emissions of local and regional air pollutants, such as sulfur and nitrogen oxides, which in turn reduce the human health and other impacts of those emissions.

Feasibility Issues

Interaction with other programs to promote renewable energy.

Status of Group Approval

Completed.

Level of Group Support

Unanimous consent.

Barriers to Consensus

None.

ES-2. Environmental Portfolio Standard (Renewables and Energy Efficiency) with Renewable Energy Credit Trading

Mitigation Option Description

A renewable portfolio standard is a mitigation option requiring investor-owned electric utilities to supply a certain percentage of retail electricity from renewable energy sources by a stipulated date. An RPS that includes measurable, verifiable and lasting efficiency options is an EPS. Utilities can satisfy the EPS requirement by generating renewable energy themselves or by purchasing renewable energy credits (REC) from a renewable energy generator. An REC is equal to 1 kWh of eligible and verified renewable electricity produced. North Carolina has recently passed such a bill by the General Assembly of North Carolina in the 2007 Session.

Mitigation Option Design

Eligible renewable sources and energy efficiency applications are as briefly outlined in the paragraphs below:

Renewables: Solar PV; wind power; micro-hydropower (< 20MW); ocean current, tidal, and wave energy; fuel cells using renewable fuels; and biomass including hog waste using an innovative waste management system that does not employ a lagoon, non-woody energy crops, wood wastes, anaerobically digested waste biomass, and other animal waste biomass.

Efficiency: Applications that provide measurable, verifiable, long-term savings to the retail customer compared with current technology in use, including but not limited to appliances; heating, ventilation, and air conditioning (HVAC); and efficient motors.

Goals: A 20% EPS by 2020, starting in 2008, with a minimum of 10% renewable generation by 2017. The RPS ramps up 1%/year over the 2008–2017 period.

Timing: as noted above.

Coverage of Parties: All power producers operating qualifying renewable facilities in North Carolina would participate.

Other: Not applicable.

Implementation Mechanisms

This is a command/control mitigation option requiring a legislative act by the North Carolina General Assembly, and/or mandated by the NCUC, within their jurisdiction.

Related Policies/Programs in Place

NC GreenPower and RPS Cost-Benefit Study.

Type(s) of GHG Reductions

Carbon dioxide from displaced coal, natural gas (NG) combined cycle, and combustion turbine facilities; methane through the use of animal waste-to-energy and landfill gas-to-energy (LFGE) resources; and aerosols from displaced coal.

Estimated GHG Savings and Costs per $MtCO_2e$

The following three sensitivities were analyzed for the EPS:

- Original targets: this corresponds to a 31% combined energy efficiency and renewable energy target by 2020.
- 20% target: this corresponds to a 20% combined energy efficiency and renewable energy target by 2020.
- Load growth offset target: this corresponds to a percent combined energy efficiency and renewable energy target by 2020 that offset load growth over that period.

For each of the above sensitivities, Table F-5 summarizes the annual GHG reductions in 2010 and 2020, the cumulative GHG reductions through 2020, the incremental cost of the option (expressed in net present value terms), and the cost-effectiveness of the option (expressed in terms of $\$/tCO_2e$).

Table F-5. Annual GHG reductions through 2020

Sensitivity	GHG Reductions ($MMtCO_2e$)			NPV of Costs (million 2005$)	Cost of Saved Carbon (2005$/$tCO_2e$ avoided)
	2010	2020	Total (2007–2020)		
Original EPS analysis (default assumptions)	6.9	44.3	288.7	$1,634	$5.7
20% combined EPS target by 2020 (default assumptions)	5.9	23.4	166.2	$410	$2.5
Combined EPS target offsetting demand growth (default assumptions)	5.5	22.3	160.2	$394	$2.5

NPV = net present value

Data Sources: EIA's AEO for 2006; "Clean Energy Technologies: A Preliminary Inventory of the Potential for Electricity Generation" by Owen Bailey and Ernst Worrell, LBNL-57451, April 2005; LaCapra Associates, 2006, "Analysis of a Renewable Portfolio Standard for the State of North Carolina," December.

Quantification Methods: The analysis used a simple spreadsheet tool to compare the aggregated costs and the efficiency and renewable components of the EPS scenario and will involve the following steps:

- Identify the type of renewable generation that would most likely be used to meet the EPS' renewable energy targets of 10% by 2017 using a cost curve approach and taking into account the magnitude of renewable energy resources in North Carolina.

- Identify the types of efficiency measures needed to meet the EPS's energy efficiency targets by 2020 in coordination with the RCI TWG.
- Estimate the incremental costs of the energy efficiency and renewable generation to meet the targets on a societal costs basis.
- Estimate the amount of CO_2 emissions that are expected to be avoided by the renewables, relative to the reference case, from the EPS.

Key Assumptions: The NC RPS is met with a combination of the resources as indicated under mitigation option design. Wind will likely represent a large share of the resources. The cost of renewable generation will include costs associated with connecting renewable technologies to the electric grid and transmitting the renewable generation to loads.

Analytical issues: Several assumptions were made in quantifying the GHG reduction benefits and cost-effectiveness of this option, as follows:

- *Renewable energy mix:* See the discussion under ES-1. The same default assumptions were used.
- *Levelized costs:* See the discussion under ES-1.
- *Avoided costs:* See the discussion under ES-1.
- *Marginal impact of energy efficiency and renewable generation:* The total level of projected electricity generation displaced by the energy efficiency and renewable energy component of the EPS exceed total projected generation from load growth. This occurs in 2016. For this year onward, it was assumed that existing coal units that were built prior to the enactment of New Source Performance Standards in 1977 would be retired. It was assumed that these plants are fully depreciated and that incremental costs of the option should be calculated relative to their fuel and O&M costs only.

New renewable generation for the original target: The graphs in Figures F-4a and F-4b show the total incremental renewable generation assumed to come on line between 2003 and 2020, as well as the new renewable generation mix in 2020 for the original analysis (i.e., the 31% target).

Figure F-4a. Estimated renewable generation increase for the original analysis of the environmental portfolio standard

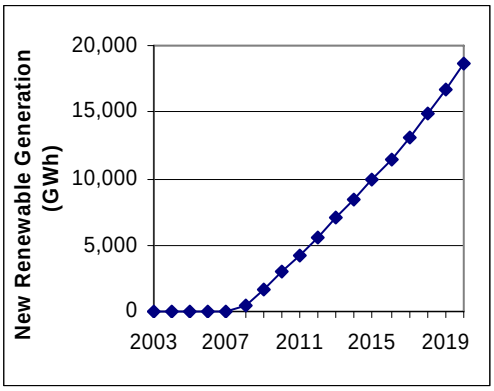
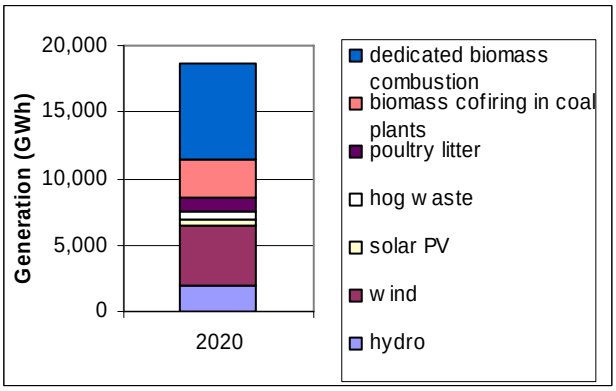


Figure F-4b. Projected mix of renewable generation for the original analysis of the environmental portfolio standard: 2020



New renewable generation for the 20% combined target: The graphs in Figures F-5a and F-5b show the total incremental renewable generation assumed to come on line between 2003 and 2020, as well as the new renewable generation mix in 2020 for the first sensitivity analysis (i.e., the 20% combined target).

Figure F-5a. Estimated renewable generation increase for the combined 20% target analysis of the environmental portfolio standard

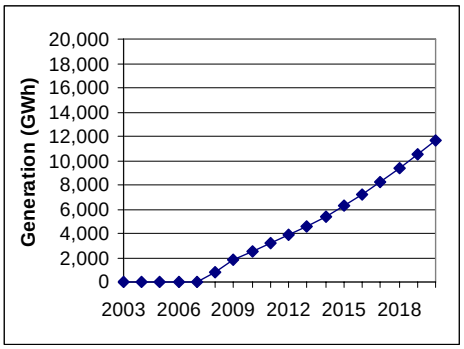
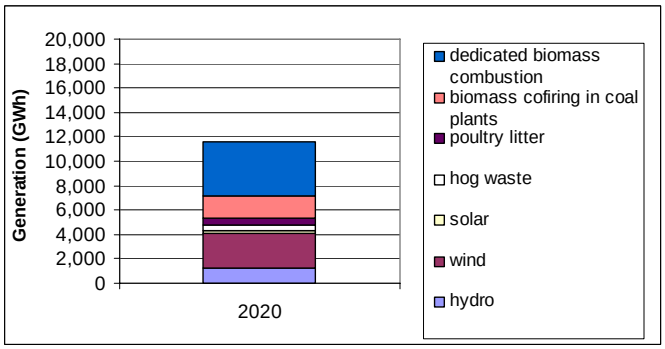


Figure F-5b. Projected mix of renewable generation for the combined 20% target analysis of the environmental portfolio standard: 2020



New renewable generation for the load growth offset target: The graphs in Figures F-6a and F-6b show the total incremental renewable generation assumed to come on line between 2003 and 2020, as well as the new renewable generation mix in 2020 for the second sensitivity analysis (i.e., the load offset target).

Figure F-6a. Estimated renewable generation increase for the load offset target analysis of the environmental portfolio standard

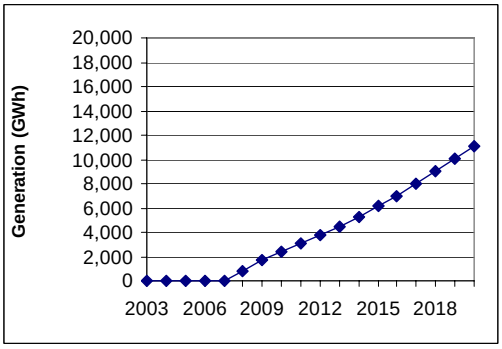
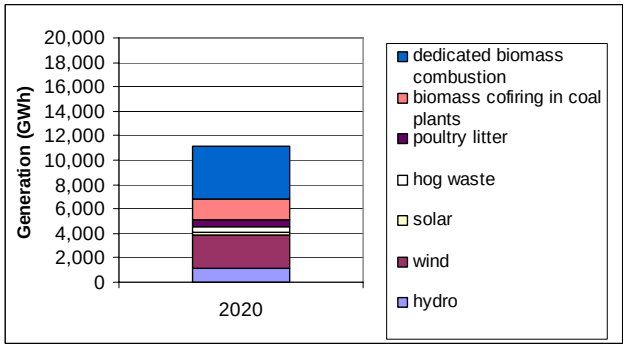
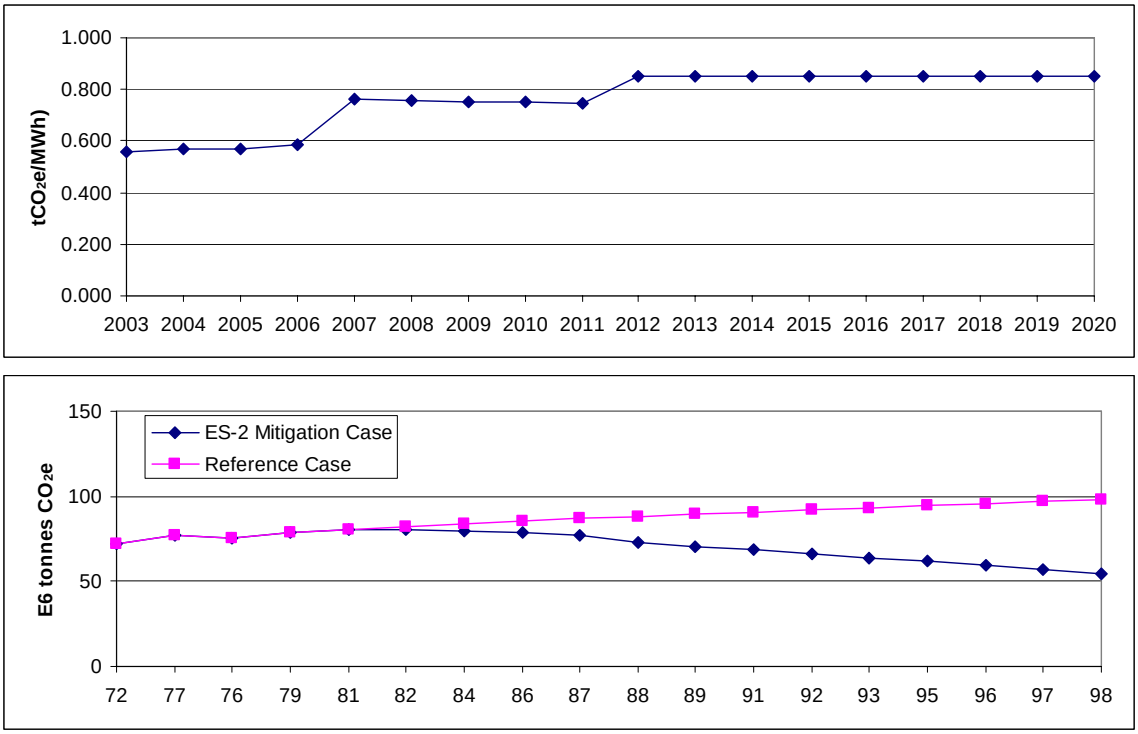


Figure F-6b. Projected mix of renewable generation for the load offset target analysis of the environmental portfolio standard: 2020



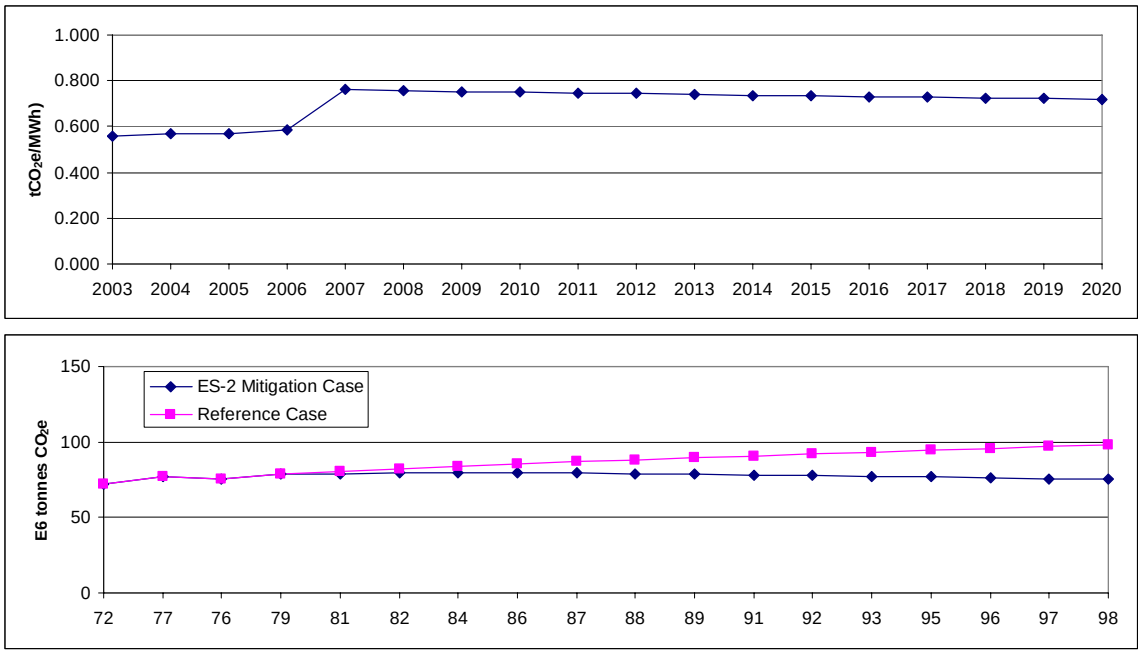
System CO_2e emission factor and emission reductions for the original target: The top graph in Figure F-7 shows the average emission factor associated with resources displaced under default assumptions for the EPS option. The bottom graph in Figure F-7 shows annual CO_2e emissions from North Carolina's electricity sector before and after the introduction of the EPS.

Figure F-7. Top = average emission factor with resources displaced with original EPS target; bottom = annual CO_2e emissions from electricity sector before and after original EPS.



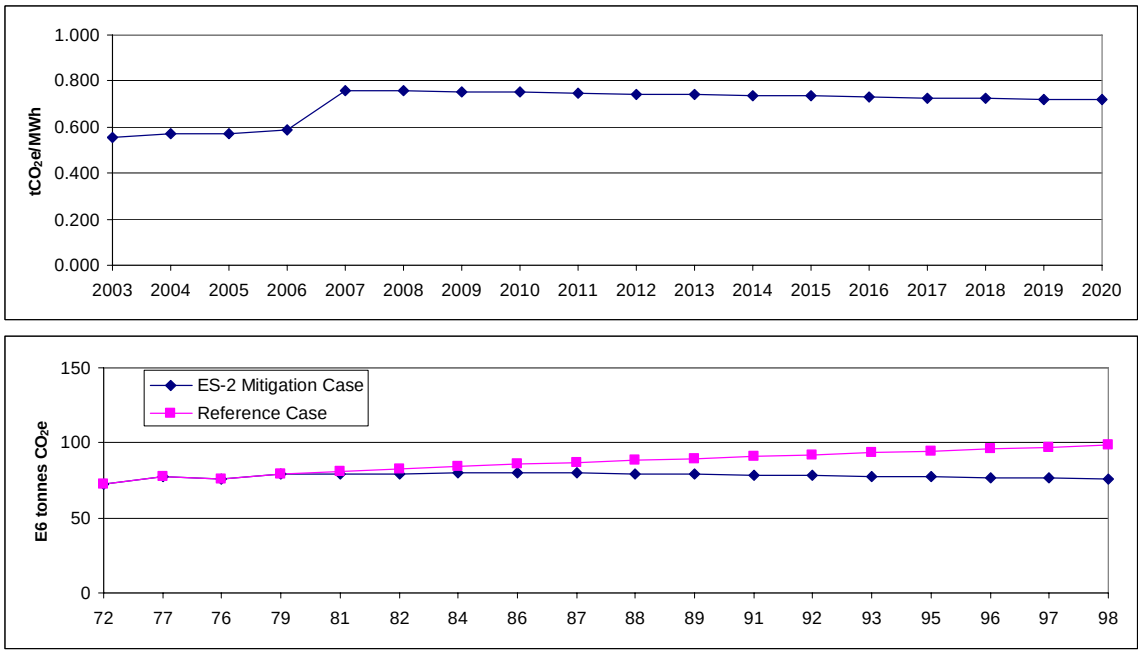
System CO_2e emission factor and emission reductions for the 20% combined target: The top graph in Figure F-8 shows the average emission factor associated with resources displaced under the assumption of a lower EPS target relative to the original analysis. The bottom graph in Figure F-8 shows annual CO_2e emissions from North Carolina's electricity sector before and after the introduction of the revised EPS.

Figure F-8. Top = average emission factor with resources displaced with 20% combined EPS target; bottom = annual CO_2e emissions from electricity sector before and after 20% combined EPS



System CO_2e emission factor and emission reductions for the load growth offset target: The top graph in Figure F-9 shows the average emission factor associated with resources displaced under the assumption of an even lower EPS target relative to the original analysis. The bottom graph in Figure F-9 shows annual CO_2e emissions from North Carolina's electricity sector before and after the introduction of the revised EPS.

Figure F-9. Top = average emission factor with resources displaced with load growth offset EPS target; bottom = annual CO_2e emissions from the electricity sector before and after load growth offset EPS target.



Rate impacts: A number of sensitivities were conducted to explore rate impacts associated with this mitigation option. See the discussion under ES-1 for the method used to calculate rate impacts. A summary of rate impacts for each of the sensitivities is shown in Table F-6. Under default assumptions (i.e., central cost inputs), rate impacts range from 0.095 c/kWh to 0.189 c/kWh. Under the high cost input assumptions with solar PV set-asides, rate impacts range from 0.110 c/kWh to 0.22 c/kWh. Under the low-cost input assumptions with solar PV set-asides, rate impacts range from 0.086 c/kWh to 0.171 c/kWh.

Table F-6. Summary of rate impacts for each sensitivity

		GHG Reductions ($MMtCO_2e$)					2020 Rate Impact (2005 c/kWh)		
	Option Name	2010	2020	Total (2007–2020)	NPV of Costs (million 2005$)	Cost of Saved Carbon (2005$/$tCO_2$ avoided	Energy Effi-ciency	Renew-able Energy	Total
ES-2a	**ES-2 Environmental Portfolio Standard**								
1	Original analysis (default assumptions)	6.94	44.33	288.73	$1,634	$5.7	0.075	0.113	0.1888
2	Original analysis–low levelized cost estimate	6.94	44.33	288.73	$43	$0.1	0.075	0.092	0.1671
3	Original analysis–high levelized cost estimate	6.94	44.33	288.73	$3,224	$11.2	0.075	0.135	0.2105
4	Original analysis–central levelized cost estimate (2% solar PV set-aside)	6.94	44.33	288.73	$1,847	$6.4	0.075	0.119	0.1939
5	Original analysis–low levelized cost estimate (2% solar PV set-aside)	6.94	44.33	288.73	$191	$0.7	0.075	0.095	0.1707
6	Original analysis–high levelized cost estimate (2% solar PV set-aside)	6.94	44.33	288.73	$3,504	$12.1	0.075	0.142	0.2172
ES-2b	**EPS—20% Combined Target by 2020**								
1	20% target analysis (default assumptions)	5.90	23.37	166.20	409.80	2.47	0.042	0.064	0.1063
2	20% target analysis–low levelized cost estimate	5.90	23.37	166.20	–645.54	–3.88	0.042	0.052	0.0941
3	20% target analysis–high levelized cost estimate	5.90	23.37	166.20	1,465.15	8.82	0.042	0.076	0.1185
4	20% target analysis–central levelized cost estimate (2% solar PV set-aside)	5.90	23.37	166.20	552.85	3.33	0.042	0.067	0.1092
5	20% target analysis–low levelized cost estimate (2% solar PV set-aside)	5.90	23.37	166.20	–546.29	–3.29	0.042	0.054	0.0960
6	20% target analysis–high levelized cost estimate (2% solar PV set-aside)	5.90	23.37	166.20	1,651.98	9.94	0.042	0.080	0.1223
ES-2c	**EPS—Combined Target Offsetting Demand Growth**								
1	Demand growth offset analysis (default assumptions)	5.53	22.29	160.25	393.95	2.46	0.037	0.058	0.0951
2	Demand growth offset analysis–low levelized cost estimate	5.53	22.29	160.25	–623.56	–3.89	0.037	0.047	0.0840
3	Demand growth offset analysis–high levelized cost estimate	5.53	22.29	160.25	1,411.46	8.81	0.037	0.069	0.1061
4	Demand growth offset analysis–central levelized cost estimate (2% solar PV set-aside)	5.53	22.29	160.25	531.87	3.32	0.037	0.060	0.0976
5	Demand growth offset analysis–low levelized cost estimate (2% solar PV set-aside)	5.53	22.29	160.25	–527.86	–3.29	0.037	0.048	0.0858
6	Demand growth offset analysis–high levelized cost estimate (2% solar PV set-aside)	5.53	22.29	160.25	1,591.60	9.93	0.037	0.072	0.1095

2005 c/kWh = cents per kilowatt hour in 2005 dollars; NPV = net present value

Solar thermal: The ES TWG has opted to include solar thermal results in its results. This is in contrast to the approach adopted thus far to include these results as part of the RCI TWG results. Table F-7 shows the costs and benefits of solar thermal technology as computed from the penetration targets used in the RCI TWG.

Table F-7. Costs and benefits of solar thermal technology

Option No.	Option Name	GHG Reductions ($MMtCO_2e$)			NPV of Costs (million 2005$)	Cost of Saved Carbon (2005$/$tCO_2e$ avoided)
		2010	2020	Total (2007–2020)		
RCI-3	Solar thermal hot water/space heat/space cooling for government sector (Energy Efficiency Requirements for Government Buildings)	0.00	0.10	0.20	$3.44	$16.89
RCI-7	Solar thermal hot water/space heat/space cooling for commercial/residential (Beyond Code—Building Design Incentives and Targets, Incorporating Local Building Materials and Advanced Construction)	0.02	0.15	0.33	$7.94	$23.84
RCI-10	Solar hot water for residential sector (Distributed Renewable and Clean Fossil Fuel Power Generation)	0.04	0.21	0.80	$35.35	$43.98

NPV = net present value

Key Uncertainties

- North Carolina–specific costs of energy supply technologies modeled.
- Marginal impact of energy efficiency and renewable generation on system dispatch in North Carolina.

Additional Benefits and Costs

Introducing additional renewable generation also reduces emissions of local and regional air pollutants, such as sulfur and nitrogen oxides, which in turn reduce the human health and other impacts of those emissions.

Feasibility Issues

Interaction with other programs to promote renewable energy and energy efficiency.

Status of Group Approval

Completed.

Level of Group Support

Unanimous Consent.

Barriers to Consensus

None.

ES-3 and ES-9. Removing Barriers and Providing Incentives to Combined Heat and Power (CHP) and Clean DG

Mitigation Option Description

Combined heat and power (CHP), also know as co-generation, is a method of utilizing the thermal energy (heat) produced when generating electricity (power) in a single, coordinated process. CHP is more energy efficient than separate generation of electricity at a separate central electric plant and production of localized thermal energy for the end user. This distributed generation (DG) resource allows for recycling the heat, which is normally wasted to cooling towers or lakes at centralized electricity generating stations, to meet on-site thermally driven demand such as process and space heating, cooling, and dehumidification.

Mitigation Option Design

The proposed mitigation option encourages adoption of CHP through a combination of regulatory improvements and expanded incentives designed to improve interconnection and net metering standards, adopt output based emission standards, and allow GHG friendly business arrangements, such as third party ownership of CHP-based generation.

Goals: 50% of North Carolina's 4,000 MW (megawatts) of planned new electricity generation will be CHP.

Timing: Goal should be achieved by 2018, within the time frame for new generation additions.

Coverage of Parties: NCUC, utilities, NC Sustainable Energy Association.

Other: Not applicable.

Implementation Mechanisms

This is a command and control mitigation option that would be implemented with the following steps: (1) Encourage CHP systems of 20 MW or smaller (or of equivalent mechanical power) by a speedy adoption and customer-friendly implementation of the Federal Energy Regulatory Commission (FERC) Order 2006 Standardization of Small Generator Interconnection Agreements and Procedures, (2) qualify recycled energy from CHP generation for existing renewable and energy efficiency incentive and loan programs, (3) allow energy service companies to sell CHP and customer-operated distributed generation (CDG) output to third-party customers, and (4) facilitate governmental and nonprofit organizations to easily sell renewable energy credits and tax credits to the market place.

Related Policies/Programs in Place

The mitigation option design statements point to key related policies and programs which already exist in North Carolina, at the national level and other states such as Connecticut, New York, Texas, and California for successfully implementing CHP and CDG.

Type(s) of GHG Reductions

Substantial carbon dioxide reductions would be achieved from displaced coal generation.

Estimated GHG Savings and Costs per $MtCO_2e$

The table below summarizes the annual GHG reductions in 2010 and 2020, the cumulative GHG reductions through 2020, the incremental cost of the option (expressed in net present value terms), and the cost-effectiveness of the option (expressed in terms of $\$/tCO_2e$ avoided).

Option No.	Option Name	GHG Reductions ($MMtCO_2e$)			NPV of Costs (million 2005$)	Cost of Saved Carbon (2005$/$tCO_2e$ avoided)
		2010	2020	Total (2007–2020)		
ES-3 & ES-9	CHP incentives and barrier removal	0.7	2.8	20.1	$128	$6.4

NPV = net present value

Data Sources: EIA's AEO for 2006; *Combined Heat and Power White Paper*, January 2006, prepared for the Clean and Diversified Energy Initiative of the Western Governors Association based on a study in 2003 for USDA's National Renewable Energy Laboratory (NREL) by Energy and Environmental Analysis.

Quantification Methods: The proposed analysis will use a simple spreadsheet tool to evaluate the costs and benefits associated with introducing 2,000 MW over the study period. It will involve the following steps

- The starting point for the analysis was to develop a better understanding of the CHP in North Carolina, based on a review of available studies. This helped to confirm a key assumption of the analysis that there exists at least 2,000 MW of CHP potential by 2020, as well as identify a working split between commercial and industrial CHP.
- Integrate assumptions regarding the penetration of and fuel shares for new CHP systems, estimates of future capacity of CHP developed under the mitigation option, and CHP cost and performance for different kinds of systems into a spreadsheet model to estimate the overall net GHG emissions reduction and net cost of the mitigation option. The avoided GHG emissions will be estimated in a manner consistent with the analysis of demand reduction options in RCI.

Key Assumptions: A key assumptions is that CHP potential is at least 2,000 MW and can be phased in at an acceptable rate. Systems are assumed to operate an average of 5,000 hours/year (at full capacity), and 90% of co-generated heat is assumed to be usable (and displaces heat from purchased fuels). Gas-fired, biomass-fired, and coal-fired capacity are assumed, with a mix that includes a heavy reliance on natural gas.

Analytical Issues: There were several assumptions that were made in quantifying the GHG reduction benefits and cost-effectiveness of this option, as follows:

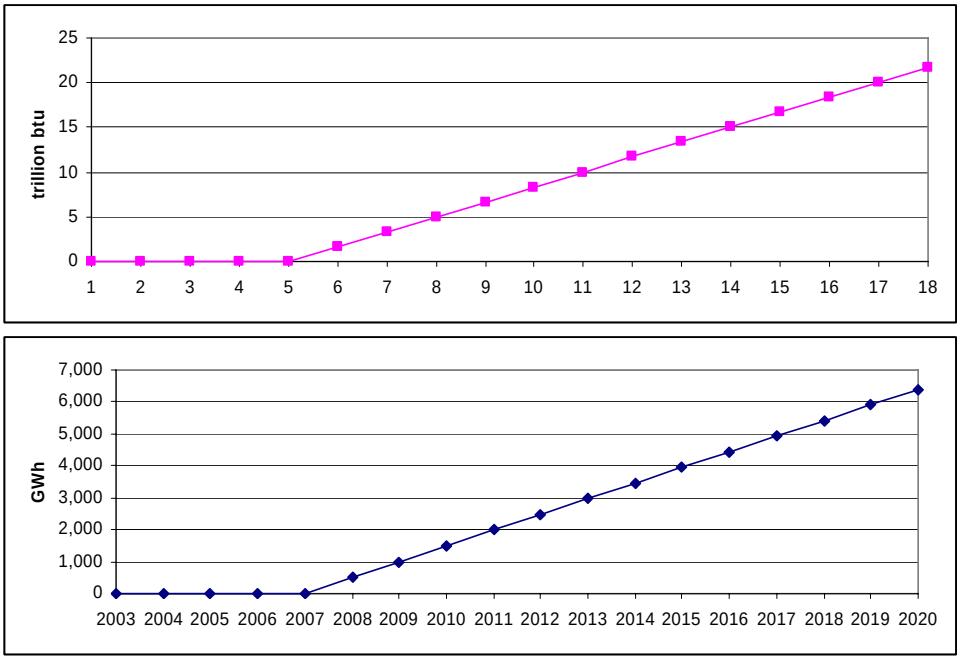
- *CHP targets:* The CAPAG indicated that a sensitivity analysis should be conducted regarding the level of penetration of CHP systems. Hence, the analysis was set up to consider the following sensitivities.

  1. 50% of the target is met: This corresponds to 1,000 MW of new CHP capacity. **Note that this is the default assumption and the results reflect this assumption.**

  2. 90% of the target is met: This corresponds to 1,800 MW of new CHP capacity.

- *Fuel mix:* It was assumed that the fraction of new CHP capacity fueled with NG was 90%, with the remaining 10% split evenly between biomass and coal.
- *Energy and system electricity displaced by CHP:* CHP electricity production characteristics as well and system transmission and distribution (T&D) losses were accounted for to estimate annual fuel and system electricity generation displaced, as shown in Figure F-10.

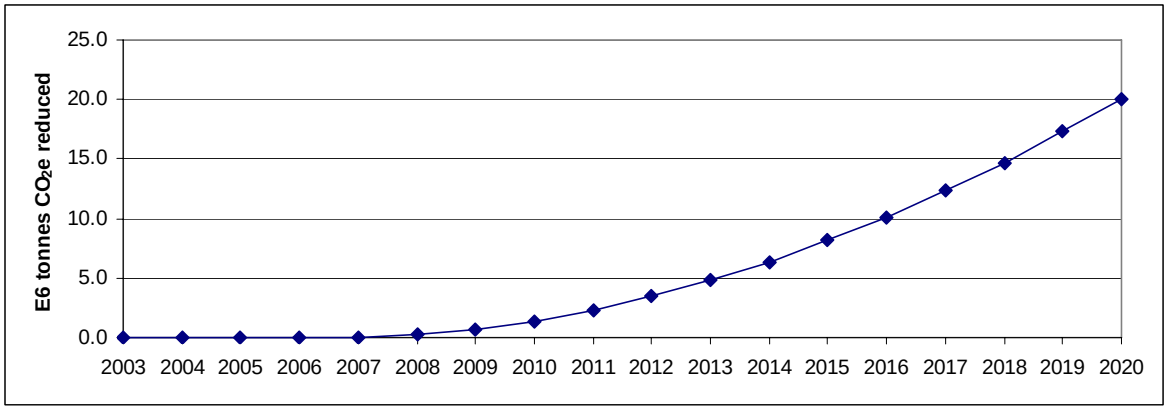
Figure F-10. Top = net displaced fuel use after accounting for net efficiency; bottom = electricity generation from CHP facilities



- *Marginal impact of CHP:* See the discussion under ES-1. The same default assumptions were used.

CO_2e emission factor and cumulative emission reductions: See the discussion under ES-1 for electricity supply. The same default assumptions were used. For fuel, standard Intergovernmental Panel on Climate Change (IPCC) emission factors were used for natural gas, coal, biomass, and oil. Figure F-11 shows cumulative CO_2e emission reductions associated with CHP systems.

Figure F-11. Cumulative CO_2e emission reductions with CHP systems



Key Uncertainties

- CHP potential in North Carolina.
- Heating fuels to be displaced by cogeneration
- Future cost and performance characteristics of CHP systems.

Additional Benefits and Costs

Reduction of losses associated with T&D.

Feasibility Issues

Interconnection with electric system grid.

Status of Group Approval

Completed.

Level of Group Support

Unanimous consent.

Barriers to Consensus

None.

ES-4. CO_2 Tax and/or Cap-and-Trade (Covering Sources Including Fossil, Renewable, and Nuclear on Life Cycle Basis)

Mitigation Option Description

A cap-and-trade system is a market mechanism in which CO_2 and other GHG emissions are limited or capped at a specified level, and those participating in the system can trade permits (a permit is an allowance to emit one ton of CO_2 and GHG) in order to lower costs of compliance. For every ton of CO_2 and GHG released, an emitter must hold a permit. Therefore, the number of permits issued or allocated is, in effect, the cap. The government can give permits away for free (according to any one of many different criteria to those participating in the cap-and-trade system or even to those who are not), auction them, or a combination of the two. Participants can range from a small group within a single sector to the entire economy and can be implemented upstream (at the level of fuel extraction or import) or downstream at the points where fuel is consumed.

Mitigation Option Design

A cap-and-trade program applicable to North Carolina sources would be implemented on a national or regional (i.e., multi-state) basis. A program covering the power sector alone was analyzed. It is important to note that the purpose of assessing a cap-and-trade program within the TWG process is to consider the GHG reductions and costs (or cost savings) of such a mitigation option, not to define the details of a prospective regulatory program.

Goals: GHG intensity reduction of about 2%/year over the 2010–2020 period.

Timing: Program start-up in 2008, or as soon as practicable.

Coverage of Parties: NCUC, utilities.

Other: Not applicable.

Implementation Mechanisms

This is a market-based mechanism with an underlying regulatory obligation.

Related Policies/Programs in Place

No cap-and-trade system is in place in North Carolina.

Type(s) of GHG Reductions

A cap-and-trade system will impose a direct limit on CO_2 emissions. Reductions are determined by the level of the cap. To the extent that generation from coal and oil declines under a cap-and-trade system, black carbon emissions will also decrease.

Estimated GHG Savings and Costs per $MtCO_2e$

The table below summarizes the annual GHG reductions in 2010 and 2020, the cumulative GHG reductions through 2020, the incremental cost of the option (expressed in net present value terms), and the cost-effectiveness of the option (expressed in terms of $/$tCO_2e$ avoided).

Option No.	Option Name	GHG Reductions ($MMtCO_2e$)			NPV of Costs (million 2005$)	Cost of Saved Carbon (2005$/$tCO_2e$ avoided)
		2010	2020	Total (2007–2020)		
ES-4	GHG Cap-and-trade					
	Electricity sector only	0.8	3.3	20.4	$119	$5.81
	Economy-wide	1.8	7.1	47.7	$284	$5.95

NPV = net present value

Data Sources: EIA report (see below).

Quantification Methods: A parameterization approach was used to assess this mitigation option. This is due to the fact that the analysis of a cap-and-trade system in North Carolina would be highly complex involving sophistical modeling techniques and difficult to do well given time and resource constraints. The parameterization techniques involve the downscaling of results of the GHG cap-and-trade study done by the EIA in a Congressional Service Report from March 2006 titled *"Energy Market Impacts of Alternative Greenhouse Gas Intensity Reduction Goals"* based on the use of the National Energy Modeling System (NEMS) model based on the Annual Energy Outlook of 2006. This is an updated analysis of an earlier EIA report titled: *"Impacts of Modeled Recommendations of the National Commission on Energy Policy"* dated April 2005 which had been prepared by the EIA using the Annual Energy Outlook of 2005 in response to a request from Senator Jeff Bingaman, ranking Minority Member of the U.S. Senate Committee on Energy and Natural Resources, to assess the impact of a GHG cap-and-trade policy for the United States, among other things.

Key Assumptions: The EIA study is a national study, which can be downscaled for application to North Carolina using parameterization techniques.

Analytical Issues: There were several assumptions that were made in quantifying the GHG reduction benefits and cost-effectiveness of this option, as follows:

- *Analysis cases:* Per direction from the CAPAG, the ES TWG considered two cases. The first case assumes that a cap (expressed as a carbon intensity per unit of economic output) is placed only on the electricity sector. The second case assumes that a cap (expressed as a carbon intensity per unit of economic output) is placed on the electricity and demand sectors.

Scenarios analyzed: The analysis upon which the parameterization is based considered the following four scenarios:

1. *Cap-and-trade #1:* This assumes a GHG intensity (tCO_2/$ of output) reduction of 2.4%/year, economy-wide, between 2010 and 2019. The trading price is $6.16/$tCO_2e$ and

$9.86/t$CO_2$e in 2010 and 2020, respectively. **Note that this is the default assumption and the results reflect this assumption.**

2. *Cap-and-trade #2:* This assumes a GHG intensity reduction of 2.6%/year between 2010 and 2019. The trading price is $8.83/t$CO_2$e and $14.13/t$CO_2$e in 2010 and 2020, respectively.

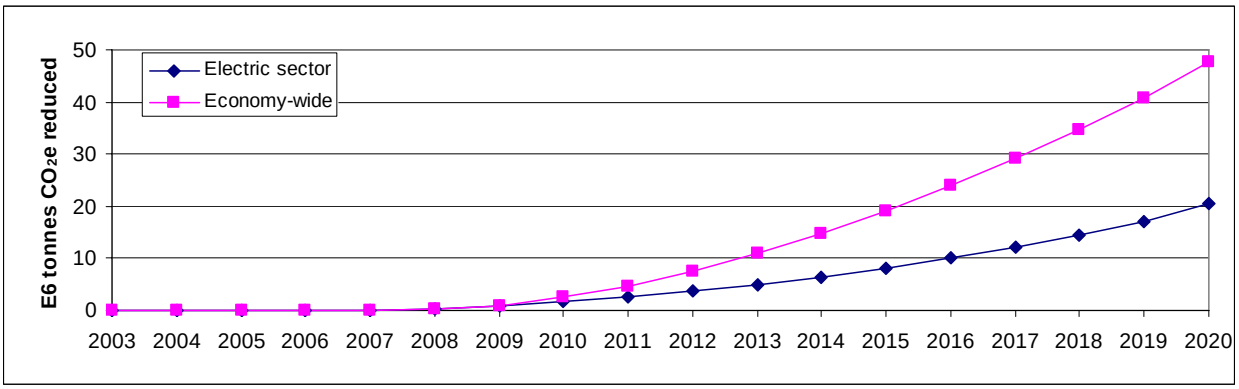
3. *Cap-and-trade #3:* This assumes a GHG intensity reduction of 2.8%/year between 2010 and 2019. The trading price is $22.09/t$CO_2$e and $35.34/t$CO_2$e in 2010 and 2020, respectively.

4. *Cap-and-trade #4:* This assumes a GHG intensity reduction of 3.0%/year between 2010 and 2019. The trading price is $30.92/t$CO_2$e and $49.47/t$CO_2$e in 2010 and 2020, respectively.

- *Parameterization approach:* It was assumed that a national cap-and-trade system had been implemented per the EIA analysis. The aim of the parameterization is to extract the impact on North Carolina from the application of this national policy. A simple scaling from the national to the state level was performed based on the percent GHG reductions from the Reference Case. Total costs of the mitigation option were calculated on the basis of the GHG reduction achieved in North Carolina and the national credit price.

CO_2e cumulative emission reductions: Figure F-12 shows cumulative CO_2e emission reductions in the North Carolina electricity sector and economy-wide associated with the cap-and-trade option.

Figure F-12. Cumulative CO_2e emission reductions in electricity sector and economy-wide with cap-and-trade option



Rate impacts: A number of sensitivities were conducted to explore rate impacts associated with this mitigation option. See the discussion under ES-1 for the method used to calculate rate impacts.

The sensitivity analyses are associated with the safety valve price (i.e., the safety-valve is an agreement by the government to sell emission permits at a given price so as to limit the potential permit cost to a maximum. The government is assumed to sell permits sufficient to make up the difference between covered emissions and the emissions goal. As a result, the government begins

to accrue additional permit revenue once the safety-valve price is reached). A summary of rate impacts for each of the sensitivities is presented in Table F-8.

Table F-8. Summary of rate impacts for each sensitivity

Option No.	Option Name	2020 Rate Impact (2005 c/kWh)		
		Energy Efficiency	Renewable Energy	Total
ES-4	**Cap GHG and Trade–Electricity Sector Only**			
	Safety valve price trajectory #1			0.0038
	Safety valve price trajectory #2			0.0085
	Safety valve price trajectory #3			0.0577
	Safety valve price trajectory #4			0.1139
ES-4	**Cap GHG and Trade–Economy-wide**			
	Safety valve price trajectory #1			0.0035
	Safety valve price trajectory #2			0.0078
	Safety valve price trajectory #3			0.0579
	Safety valve price trajectory #4			0.1201

2005 c/kWh = cents per kilowatt hour in 2005 dollars.

Key Uncertainties

North Carolina–specific impacts of a national cap-and-trade system.

Additional Benefits and Costs

An economy wide cap-and-trade system would achieve substantially higher GHG reductions at a small incremental cost.

Feasibility Issues

Allowance allocation and other design issues.

Status of Group Approval

Completed.

Level of Group Support

Supermajority of support (two objections).

Barriers to Consensus

Resolution of the coverage issues (i.e., desirability of a national vs. a state-specific cap-and-trade system).

ES-5. Aligning Environmental and Profit Incentives Through Electricity Sector Regulatory/Rate Reform

Mitigation Option Description

Several regulatory and rate reforms in North Carolina would encourage electric utilities to invest in clean, non-carbon–producing energy resources such as renewables and energy efficiency. Under the current rate structure, utilities have an incentive to invest in new large capital projects, which also may inhibit investments in energy efficiency. North Carolina could align the regulated electric utilities' profit motive with increased energy efficiency by removing perverse disincentives to energy efficiency.

Mitigation Option Design

Aligning environmental and profit incentives could be accomplished by action on the part of the Utilities Commission to reform the rate structure through (a) decoupling profits from sales volume, (b) making lost revenue adjustments, and developing inverted block rates. Moreover, the Utilities Commission should require electric utilities to consider the costs associated with future regulation of carbon dioxide emissions when evaluating both supply-side (e.g., new power plants) and demand-side (e.g., energy efficiency) resource options. Aligning environmental and profit incentives in North Carolina would involve the following:

- *Decoupling Profits from Sales*—In a decoupled rate structure, utility profits are based on their cost of service and number of customers, rather than electricity sales. Utilities are entitled to earn enough revenue to cover fixed costs plus some profit based on their projected sales. If sales exceed projections, excess revenue is returned to ratepayers through rate adjustments the following year. If sales are lower than projection, rates are increased the following year to make up the difference.
- *Lost Revenue Adjustment*—Lost revenue adjustments reward utilities for energy generation lower than anticipated levels and remove additional profits when utility generation is higher than anticipated levels. This is accomplished by allowing utilities to recover net revenues lost due to energy efficiency programs (including decreased sales plus the administrative costs of the program) via periodic rate adjustments. Thus, the incentive for ever-increasing electricity sales is removed *and* efficiency is rewarded.
- *Inverted Block Rates for Residential Customers*—Inverted block rates, in which rates increase with consumption, can encourage efficiency for residential customers by sending customers price signals that more accurately reflect the costs of producing electricity. Because each successive "block," or increment of energy used per billing period becomes progressively more expensive, inverted block rates encourage efficiency and discourage wasteful consumption. Inverted block rates can also better serve families with low incomes.
- *Require Utilities to Use a "Carbon Adder" in Resource Selection*—"Carbon adders" are a means of accounting for possible future costs of compliance with future GHG regulations. A carbon adder is an expected future price for CO_2 that is assumed when comparing resource

options. It typically involves that utilities include in the resource selection and screening process a CO_2 cost adder.

Goals: This mitigation option will not be quantified in the analysis phase, as it is too early in the process to assign goal levels. Instead, the emphasis during the analysis phase will be to define the details of a prospective rate reform program. After this process, it may be possible to assign goal levels in some future initiative.

Timing: TWG develops the initial details of a prospective rate reform program (October 2006–February 2007) and present this as an output of the NC Climate Change mitigation process. New legislation, based on the results of studies by the NCUC and the NC legislature, would set the start year for implementation of reforms to be 2009.

Coverage of Parties: Utilities Commission, regulated electric utilities, State Energy Office, environmental and public health groups

Other: Not applicable.

Implementation Mechanisms

This is a command/control options that requires changes to Utilities Commission rules and/or legislation by the General Assembly.

Related Policies/Programs in Place

Numerous other states have similar rate reform programs in place.

Type(s) of GHG Reductions

Greater reliance on renewables and energy efficiency would reduce dependence on electricity produced by burning coal and other fossil fuels, thereby reducing emissions of carbon dioxide and other GHGs.

Estimated GHG Savings and Costs per $MtCO_2e$

Data Sources: Not applicable.

Quantification Methods: Not applicable.

Key Assumptions: Not applicable.

Key Uncertainties

Interaction with other options.

Additional Benefits and Costs

Aligning environmental goals with planning protocols would reduce emissions of local and regional air pollutants and land and water impacts.

Feasibility Issues

Interaction with other programs to promote environmental quality.

Status of Group Approval

Completed.

Level of Group Support

Unanimous consent.

Barriers to Consensus

None.

ES-6. Incentives for Advanced Coal

Mitigation Option Description

Integrated gasification combined cycle (IGCC) is an emerging technology for coal power, offering the potential for higher efficiency and reduced cost of pollutant emissions control. IGCC involves partially combusting coal under high pressure to produce a synthetic gas, which is then turned into electricity via combined cycle combustion. IGCC can be combined with carbon capture and sequestration or reuse (CCSR) leading to significant CO_2 emission reductions relative to those of conventional coal technology. This technology appears to be limited only by some cost differences at this time. However, due to locations of coal sources and suitable sequestration sites, additional analysis of how this can be made viable in North Carolina is anticipated.

Mitigation Option Design

Options for advanced fossil technologies may include mandates or incentives to use advanced coal technologies for new coal plants. Mandates could take multiple forms such as (a) certain CO_2 emission rates only achievable with advanced technology, (b) specifying that new coal plants be IGCC, or (c) requiring that a certain percentage of new coal plants be IGCC or employ advanced fossil technologies. Incentives may be in the form of direct subsidies or assistance in securing financing. A combination of mandates and incentives is also possible.

Goals: At least one new IGCC power plant in North Carolina replacing a planned conventional coal addition. This goal would be reached by confirmation of technical feasibility in North Carolina and then providing an incentive equal to the marginal cost difference between conventional coal technology and new advanced coal technology (with carbon capture and/or sequestration as appropriate), currently equal to about a 20%–25% premium above the cost of pulverized coal plants. Utilities would be ensured cost recovery regardless of whether the system includes carbon capture and storage.

Timing: Program start-up as soon as possible. Tie into Certificate of Public Convenience and Necessity (CPCN) proceeding, where details regarding cost estimates and the incentive program can be developed.

Coverage of Parties: NCUC, NC-based utilities

Other: Not applicable.

Implementation Mechanisms

This is a market-based mechanism with an underlying regulatory obligation. Implementation mechanisms would need to focus on the incentive structure, research and development, technical assistance and education, and a potential pilot plant.

Related Policies/Programs in Place

Related programs include rate reform and restructuring, energy efficiency resources, and environment as a criteria for decision making, already before the NCUC in the Integrated Resource Planning proceeding. Rate programs already in place include energy conservation discount rate, time of use rates, real-time pricing, and curtailable rate options for customers.

Type(s) of GHG Reductions

Advanced fossil technologies are more efficient than conventional fossil technologies, and, therefore, have lower CO_2 emission rates. Advanced fossil technologies combined with CCSR could enable significantly lower CO_2 emissions on the order of between 11% and 90%, depending on whether carbon capture and storage is considered.

Estimated GHG Savings and Costs per $MtCO_2e$

The table below summarizes the annual GHG reductions from this option in 2010 and 2020, the **cumulative** GHG reductions through 2020, the incremental cost of the option (expressed in net present value terms), and the cost-effectiveness of the option (expressed in terms of $\$/tCO_2e$ avoided). The results are presented relative to the replacement of a new 800-MW pulverized coal unit and the replacement of an existing 800 MW coal unit. Several sensitivity analyses were conducted and are also summarized in the table below.

Option Name	GHG Reductions ($MMtCO_2e$)			NPV of costs (million 2005$)	Cost of saved carbon (2005$/$tCO_2e$ avoided)
	2010	2020	Total (2007–2020)		
IGCC with/without carbon capture & storage—replace new 800-MW plant					
With carbon capture & storage—central cost estimates	0.00	3.88	31.04	$949	$30.6
IGCC only	0.00	0.49	3.94	$46	$11.6
With carbon capture & storage—low cost estimates	0.00	3.68	29.46	$290	$9.8
With carbon capture & storage—high cost estimates	0.00	4.08	32.62	$1,664	$51.0
IGCC with/without carbon capture & storage—replace existing 800-MW plant					
With carbon capture & storage—central cost estimates	0.00	5.36	42.86	$2,061	$48.1
IGCC only	0.00	1.97	15.76	$1,158	$73.5
With carbon capture & storage—low cost estimates	0.00	5.16	41.28	$1,402	$34.0
With carbon capture & storage—high cost estimates	0.00	5.55	44.43	$2,777	$62.5

NPV = net present value

Data Sources: EIA's AEO for 2006; IPCC report titled "Carbon Capture and Storage," 2006.

Quantification Methods: As noted in the table above, we have estimated the incremental cost of IGCC (with and without carbon capture and storage) relative to new and existing pulverized coal, and the difference in emissions using a simple spreadsheet analysis, which accounts for the additional energy needed for the capture and storage processes. We estimated the costs from the following perspectives:

- IGCC only (no carbon capture and storage).
- IGCC with carbon capture and transmission via pipeline, storage and monitoring costs, assuming sequestration in deep saline aquifers near North Carolina.
- IGCC with carbon capture and transmission via truck to depleted natural gas fields in the Southwest.

Key Assumptions: Costs of IGCC and pulverized coal plants are drawn from local sources, or from alternative sources such as AEO 2006, and assumptions for capture and storage are drawn from the Electric Power Research Institute (EPRI), Massachusetts Institute of Technology (MIT), and IPCC.

Analytical issues: There were several assumptions that were made in quantifying the GHG reduction benefits and cost-effectiveness of this option, as follows:

- *IGCC targets:* It was assumed that 1,718 MW of coal capacity would be displaced.

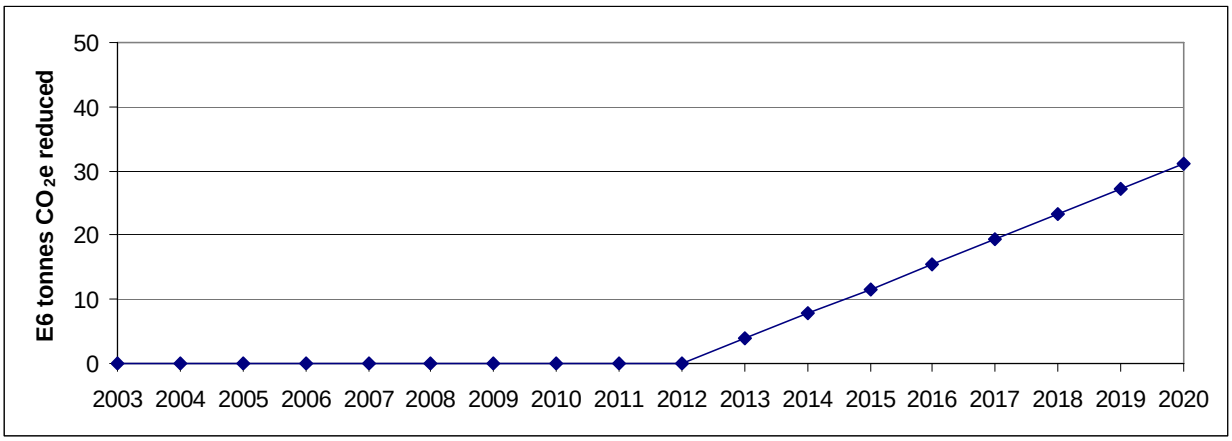
Levelized costs: Levelized cost assumptions in 2020 are provided in Table F-9. Sensitivities were considered regarding cost and performance characteristics of IGCC units with carbon capture and storage. The default assumption is the central value.

Table F-9. Levelized cost assumptions for the year 2020

Facility Type	Levelized Cost (2005$/MWh)
Pulverized coal	40.0
IGCC	53.4
IGCC with carbon capture & storage—low	43.5
IGCC with carbon capture & storage—high	102.1
IGCC with carbon capture & storage—central	71.7

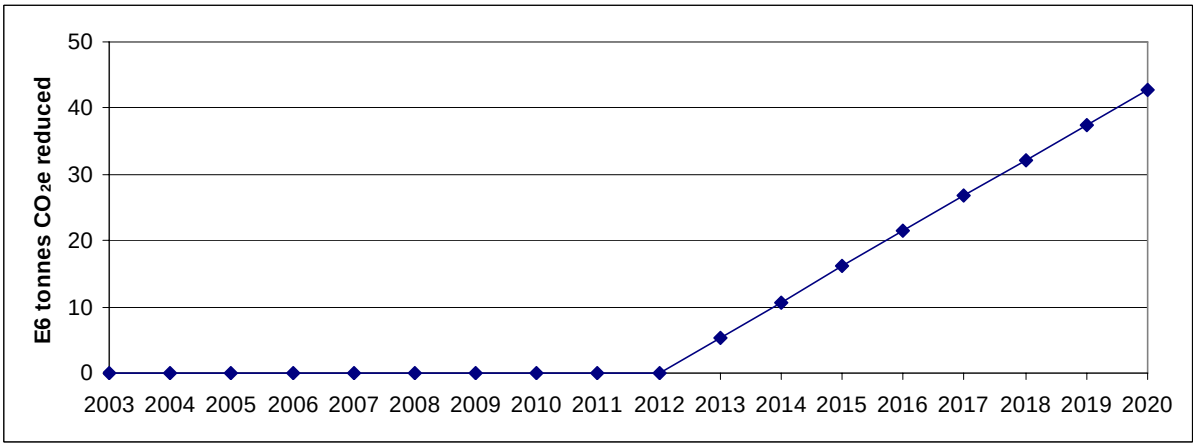
CO_2e emission factor and cumulative emissions for a new 800-MW coal station: An emission factor of 0.843 tCO_2e/MWh was used for new pulverized coal. An emission factor of 0.105 tCO_2e/MWh was used for IGCC with carbon capture and storage. Figure F-13 shows cumulative CO_2e emission reductions associated with the introduction of a large IGCC unit.

Figure F-13. Cumulative CO_2e emission reductions with large IGCC unit replacing a new 800-MW pulverized coal unit



CO_2e emission factor and cumulative emissions for an existing 800-MW coal station: An emission factor of 1.124 tCO_2e/MWh was used for pulverized coal. An emission factor of 0.405 tCO_2e/MWh was used for IGCC with carbon capture and storage. Figure F-14 shows cumulative CO_2e emission reductions associated with the introduction of a large IGCC unit.

Figure F-14. Cumulative CO_2e emission reductions with large IGCC unit replacing an existing 800 MW pulverized coal unit



Rate impacts: A number of sensitivities were conducted to explore rate impacts associated with this mitigation option. See the discussion under ES-1 for the method used to calculate rate impacts. A summary of rate impacts for each of the sensitivities is as presented in Table F-10.

Table F-10. Summary of rate impacts for each sensitivity

Option No.	Option Name	2000 Rate Impact (2005 c/kWh)		
		Energy Efficiency	Renewable Energy	Total
ES-6a	**IGCC with/without carbon capture & storage—replace new 800-MW plant**			
1	With carbon capture & storage —central cost estimates			0.0323
2	IGCC only			0.0016
3	With carbon capture & storage—low cost estimates			0.0098
4	With carbon capture & storage—high cost estimates			0.0566
ES-6b	**IGCC with/without carbon capture & storage—replace existing 800-MW plant**			
1	With carbon capture & storage —central cost estimates			0.0700
2	IGCC only			0.0393
3	With carbon capture & storage—low cost estimates			0.0476
4	With carbon capture & storage—high cost estimates			0.0943

2005 c/kWh = cents per kilowatt hour in 2005 dollars.

Key Uncertainties

- North Carolina–specific costs of energy supply technologies modeled.
- Commercial availability of carbon capture technology.
- Viability of long-term storage of captured carbon

Additional Benefits and Costs

Lower level of disruption to coal supply industry.

Feasibility Issues

Integration of carbon capture with distribution to long-term storage site.

Status of Group Approval

Completed.

Level of Group Support

Unanimous consent.

Barriers to Consensus

None.

ES-7. Public Benefits Charge on Electric Bills to Support Energy Efficiency Programs

Mitigation Option Description

A public benefits charge (sometimes call systems benefits charge) is a fee that can not be bypassed that is added to a customer's bill for a given time period, based on use. The funds collected are then provided to a third party to provide energy efficiency programming. The purpose behind public benefits charges is most often to reduce energy consumption. While efficiency carries significant air quality and GHG benefits, that is rarely a consideration for creation of a program and is precisely the reason this option is considered.

Mitigation Option Design

North Carolina already has a public benefits charge. It is the oldest such program in the United States, established in 1980 by the NCUC. The original intent was to reduce electricity demand in order to slow the need for new power plants. The current public benefits charge is $0.003567/kWh and has not changed since its inception in 1980. It translates into approximately 3 cents/month per average residential customer in North Carolina and raises approximately $3.5 million/year. For other states that have implemented a public benefits charge, the average charge is equivalent to $8.44 per customer and on average raises the equivalent of $72 million/year. In North Carolina, the public benefits charge should be increased to similar funding levels to provide for more efficiency initiatives.

Goals: Two goal levels are recommended, with the second goal dependent upon the first. The first goal is to gradually increase the public benefit charge to a funding level of $72 million/year, or equivalent to the national average. The second goal is to utilize that funding to meet about 1,000 MW/year in demand and 4,760 GWh/year (gigawatt-hours per year) in electricity consumption.

Timing: Program start-up in 2008. Linearly ramp up the increase to the public benefits charge over a 3-year period.

Coverage of Parties: Only investor-owned electric utilities are covered by the NCUC. In the current public benefits charge, municipal utilities and electric cooperatives are invited to participate while only electric cooperatives actually participate in the program.

Other: Not applicable.

Implementation Mechanisms

The most effective implementation method would be to work through the NCUC to increase funding in the established program. Not all funds would necessarily go to the same organization currently administering the fund.

Related Policies/Programs in Place

North Carolina has many fine organizations providing energy efficiency services that can be supplemented and improved with a n increase to the current funding levels.

Type(s) of GHG Reductions

A public benefits charges would displace coal-fired generation and the therefore lead to lower CO_2 emission rates in the State.

Estimated GHG Savings and Costs per $MtCO_2e$

The table below summarizes the annual GHG reductions in 2010 and 2020, the cumulative GHG reductions through 2020, the incremental cost of the option (expressed in net present value terms), and the cost-effectiveness of the option (expressed in terms of $/t$CO_2$e avoided).

Option No.	Option Name	GHG Reductions ($MMtCO_2e$)			NPV of Costs (million 2005$)	Carbon (2005$/t$CO_2$e avoided)
		2010	2020	Total (2007–2020)		
ES-7	Public benefits charge	0.82	3.42	24.36	$329.0	$13.5

NPV = net present value

Data Sources: EIA's AEO for 2006; RCI TWG inputs.

Quantification Methods: This analysis of this option was carried out in collaboration with the RCI who will take the initial analytical steps.

Key Assumptions: Cost and performance characteristics of individual energy efficiency and distributed renewable options as per assumption in the RCI TWG.

Analytical Issues: There were several assumptions that were made in quantifying the GHG reduction benefits and cost-effectiveness of this option, as follows:

Targets: The targets for the Public Benefit Fund (PBF) can be structured in various ways. Hence, the analysis was set up to consider the following sensitivities.

1. 4,760 GWh in reductions by 2020. This corresponds to a specific generation reduction target as advanced by the CAPAG for ES analysis. **Note that this is the default assumption and the results reflect this assumption**.

2. Default cost estimates for renewable energy technologies (based on EIA assumptions).

3. Low cost estimates for renewable energy technologies (based on the LaCapra study).

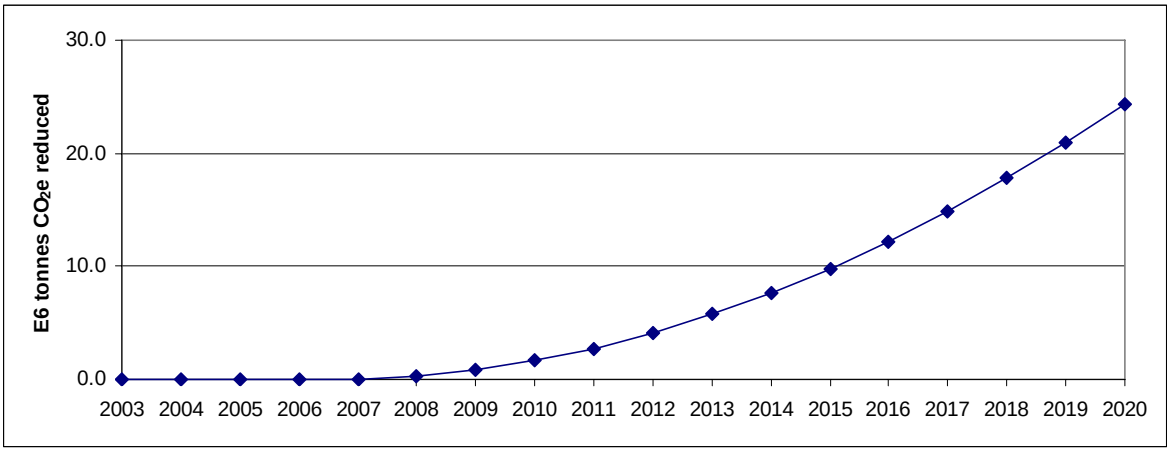
4. High cost estimates for renewable energy technologies (based on the LaCapra study).

- *Cost of efficiency measures:* A levelized costs of $46/MWh was assumed based on the results of the analysis conducted by the RCI TWG for option RCI-2.

- *Marginal impact of energy efficiency:* See the discussion under ES-1. The same default assumptions were used.

System CO_2e emission factor: See the discussion under ES-1. The same default assumptions were used to establish the average system emission factor. Figure F-15 shows the cumulative CO_2e emission reductions due to the PBF.

Figure F-15. Cumulative CO_2e emissions reductions due to PBF



Rate impacts: The rate impact associated with this mitigation option is 0.017 c/kWh.

Key Uncertainties

- North Carolina–specific costs of energy efficiency investments at savings levels modeled.
- Future expected levels of spending vs. savings from public benefits charge program in North Carolina

Additional Benefits and Costs

- Co-benefits could include transmission and distribution system cost reduction.
- Would help to provide local employment and grow renewable energy use.

Feasibility Issues

- Costs dependant on particular measures included, and therefore uncertain.
- Interaction with RCI options such as appliance standards and utility programs needs to be taken into account.

Status of Group Approval

Completed.

Level of Group Support

Supermajority of support (one objection).

Barriers to Consensus

None.

ES-8. Waste-to-Energy

Mitigation Option Description

The combustion of waste materials or their conversion by biological or thermo-chemical means can be used to produce heating, cooling, or electricity generation with lower GHG emissions than many conventional alternatives. The waste-to-energy mitigation option focuses exclusively on municipal sewage treatment (MST) to produce electricity. This is due to the fact that landfill gas (LFG), animal waste, agriculture waste, and forestry waste are all covered under the Agriculture, Forestry, and Waste Management (AFW) TWG, and direct combustion of municipal solid waste (MSW) is opposed by environmental interests.

Mitigation Option Design

The mitigation option would encourage the adoption of anaerobic digestion at MST facilities through direct subsidies to generate biogas for use in on-site engine-generators for electric power generation and heat to accelerate the treatment process. Even though the majority of generated energy will be used internally for plant operation, the municipally owned facilities should receive renewable energy credits, without having to sell the power at avoided cost and repurchasing it at retail cost.

Goals: 50% of North Carolina's new sewage treatment capacity would receive state directed funding to cover the incremental costs associated with installation and operation of on-site facilities for electrical and heat energy production from anaerobic digestion of waste sludge.

Timing: Program start-up in 2008.

Coverage of Parties: NCUC, utilities, NC Sustainable Energy Association, North Carolina Department of Environment and Natural Resources (NCDENR).

Other: Not applicable.

Implementation Mechanisms

This is a command/control mitigation option requiring a regulatory framework. The listed parties need to negotiate a satisfactory agreement, which fully values the GHG reduction benefits and the advantages to both the MST facilities and the environment for this bio-based distributed generation resource.

Related Policies/Programs in Place

There are no related policies or program currently in place in North Carolina to produce electricity or heat energy from MST.

Type(s) of GHG Reductions

Without upgrading existing treatment facilities, capturing 50% of the new anticipated growth between now and 2020 would result in significant CO_2 reductions.

Estimated GHG Savings and Costs per $MtCO_2e$

The table below summarizes the annual GHG reductions in 2010 and 2020, the cumulative GHG reductions through 2020, the incremental cost of the option (expressed in net present value terms), and the cost-effectiveness of the option (expressed in terms of $/$tCO_2e$ avoided). The target of 50% of new public municipal wastewater technical energy capacity potential (MW) by 2020 was assumed. A total potential of 2.4 MW by 2020 was assumed.

Option No.	Option Name	GHG Reductions ($MMtCO_2e$)			NPV of Costs (million 2005$)	Carbon (2005$/$tCO_2e$ avoided)
		2010	2020	Total (2007–2020)		
ES-8	Waste-to-energy	0.0003	0.0034	0.02	–$0.7	–$36.8

NPV = net present value

Data Sources: EIA's AEO for 2006; Waste chapter of Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990–2004, US EPA #430-R-06-002, April 2006; "Estimated use of water in the United States in 1990 Wastewater Treatment Water Use" by the United States Geological Survey (USGS); "Clean Energy Technologies: A Preliminary Inventory of the Potential for Electricity Generation" by Owen Bailey and Ernst Worrell, LBNL-57451, April 2005.

Quantification Methods: Incremental cost of waste-to-energy systems will be estimated relative to the most likely capacity they would displace on the system.

Key Assumptions: Not applicable.

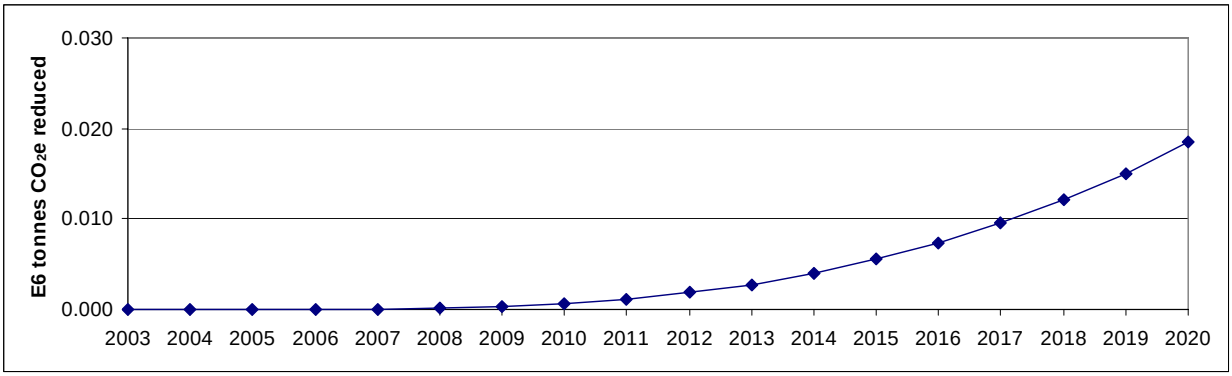
Analytical Issues: There were several assumptions that were made in quantifying the GHG reduction benefits and cost-effectiveness of this option, as follows:

- *Technical Capacity:* Technical capacity associated with municipal waste was estimated at 12.8 MW based on the USGS[2] estimate of 546 wastewater treatment public facilities in North Carolina; a net public return flow of 562 million gallons/day (also from USGS); and an assumption of 22.7 MW per million gallons/day from Bailey and Worrel.[3]
- *Targets:* A sensitivity analysis was set up to consider the following:
    1. Mid capacity target of 50% of the technical capacity by 2020. **Note that this is the default assumption and the results reflect this assumption.**
    2. Low capacity target of 20% of the technical capacity by 2020.
    3. High capacity target of 100% of the technical capacity by 2020.
    4. Marginal impact of energy efficiency and renewable generation: See the discussion under ES-1. The same default assumptions were used.

[2] Table 30 of "Estimated use of water in the United States in 1990 Wastewater Treatment Water Use" by the USGS.
[3] "Clean Energy Technologies: A Preliminary Inventory of the Potential for Electricity Generation," by Owen Bailey and Ernst Worrell, LBNL-57451, April 2005

5. System CO_2e emission factor: See the discussion under ES-1. The same default assumptions were used. Figure F-16 shows cumulative CO_2e emission reductions after the introduction of the waste-to-energy systems. The emission reductions account for the methane emissions that would otherwise be emitted to the atmosphere through anaerobic digestion.

Figure F-16. Cumulative CO_2e emission reductions with waste-to-energy systems



Rate impacts: The rate impact associated with this mitigation option is less than 0.0001 c/kWh.

Key Uncertainties

North Carolina–specific costs of technology modeled.

Additional Benefits and Costs

This option would also reduces emissions of local and regional air pollutants relative to coal-based production, such as sulfur and nitrogen oxides, which in turn reduce the human health and other impacts of those emissions.

Feasibility Issues

Interconnection with electric system grid.

Status of Group Approval

Completed.

Level of Group Support

Unanimous consent.

Barriers to Consensus

None.

ES-10. NC GreenPower Renewable Resources Program

Mitigation Option Description

NC GreenPower is an independent, nonprofit organization established by the NCUC on January 28, 2003, to improve North Carolina's environment through voluntary contributions toward renewable energy. The goal of NC GreenPower is to supplement the state's existing power supply with more green energy—electricity generated from renewable resources like the sun, wind, and organic matter. The program accepts financial contributions from North Carolina citizens and businesses to help offset the cost to produce green energy. NC GreenPower differs from a Renewable Portfolio Standard (RPS) in that the RPS requires that electric utilities provide a certain level of renewable energy capacity in their generation mix. NC GreenPower is entirely voluntary, with the revenue going toward paying incremental costs of renewable energy generation. Because all power purchased through NC GreenPower is produced inside the state, there are also economic development benefits.

Mitigation Option Design

This mitigation option aims to increase the effectiveness of the existing NC GreenPower program through a set of demand- and supply-side recommendations, as shown in Table F-11:

Table F-11. Demand- and supply-side recommendations

Demand-Side Recommendations	Supply-Side Recommendations
State facilities mandated to purchase a certain percentage of their power through NC GreenPower.	Support for research and development (R&D) on new and developing renewable energy technologies.
Provide incentives for new or expanding businesses to purchase NC GreenPower.	Provide support for feasibility studies of various renewable energy technologies.
Provide tax credits for companies purchasing from NC GreenPower or that enable employees to do.	Provide a mechanism for long-term contract guarantees for renewable energy producers.
Provide incentives for home builders to include one year of green energy through NC GreenPower with the purchase of new homes.	Provide support for larger renewable energy development projects, thereby leading to more options and sales tools.
Provide assistance and participation in consumer and business marketing programs.	Ease ridge laws in the mountains to allow for wind energy development; work with the military for wind energy in coastal areas currently blocked.
They should work with the US EPA (through NCDENR) to ensure NC GreenPower is an option for air quality (AQ) violator restitution.	Provide low or no interest loans for qualified developers of renewable energy projects.
Ensure that AQ benefits of NC GreenPower are wedded to other benefits such as waste reduction, GHG emission reductions, and economic development.	

Goals: All of North Carolina's state facilities would purchase at least 10% of their power from NC GreenPower.

Timing: Program start-up in 2008.

Coverage of Parties: NCUC, utilities, NC Sustainable Energy Association, NCDENR.

Other: Not applicable.

Implementation Mechanisms

This is a command/control mitigation option requiring a regulatory framework. The listed parties need to negotiate a satisfactory agreement, which fully values the GHG reduction benefits and the advantages to both the MST facilities and the environment for this bio-based distributed generation resource.

Related Policies/Programs in Place

There are no related policies or program currently in place in North Carolina to produce electricity or heat energy from MST.

Type(s) of GHG Reductions

Without upgrading existing treatment facilities, capturing 50% of the anticipated growth between now and 2020 would result in significant CO_2 reductions.

Estimated GHG Savings and Costs per $MtCO_2e$

The table below summarizes the annual GHG reductions in 2010 and 2020, the cumulative GHG reductions through 2020, the incremental cost of the option (expressed in net present value terms), and the cost-effectiveness of the option (expressed in terms of $/$tCO_2e$ avoided).

Option No.	Option Name	GHG Reductions ($MMtCO_2e$)			NPV of Costs (million 2005$)	Carbon (2005$/$tCO_2e$ avoided)
		2010	2020	Total (2007–2020)		
ES-10	Strengthening the NC GreenPower program	0.01	0.16	0.95	$35.1	$37.0

NPV = net present value

Data Sources: EIA's AEO for 2006, RCI TWG inputs.

Quantification Methods: This analysis of this option will be carried out in collaboration with the RCI who will take the initial analytical steps.

Key Assumptions: Cost and performance characteristics of individual energy efficiency and distributed renewable options as per assumption in the RCI TWG.

Analytical issues: The following assumptions were made in quantifying the GHG reduction benefits and cost-effectiveness of this option:

Targets: The targets were defined relative to the total generation needed to meet state demand for electricity (i.e., 2,890 GWh in 2020). It was assumed that the target is achieved entirely with renewable energy. The analysis was set up to consider two sensitivities, as follows:

1. RCI TWG analysis: This corresponds to a 10% target (relative to projected state demand for electricity) achieved by 2017 and remaining constant thereafter. **Note that this is the default assumption and the results reflect this assumption.**

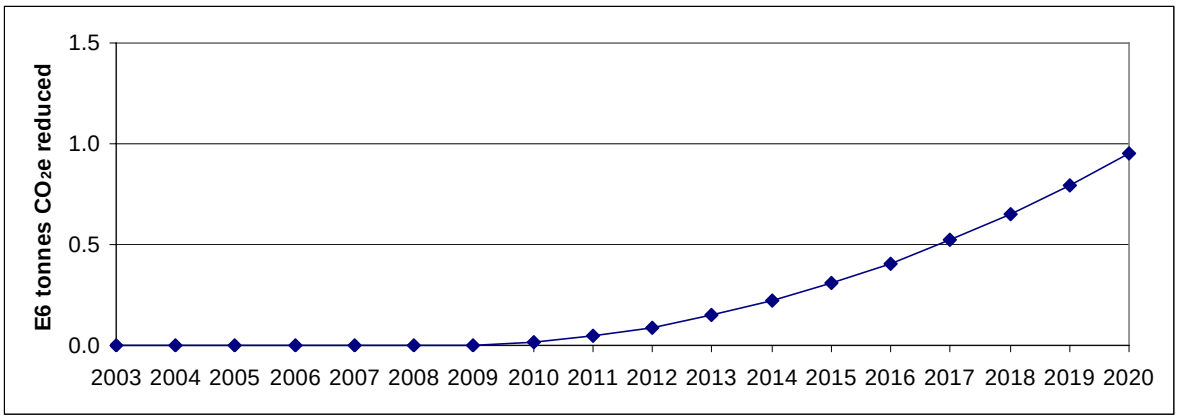
2. This corresponds to 10% target (relative to projected state demand for electricity) achieved by 2020.

Marginal impact of energy efficiency: See the discussion under ES-1. The same default assumptions were used.

Renewable energy mix: See the discussion under ES-1. The same default assumptions were used.

System CO_2e emission factor: See the discussion under ES-1. The same default assumptions were used to establish the average system emission factor. Figure F-17 shows the cumulative CO_2e emission reductions due to the strengthened GreenPower program.

Figure F-17. Cumulative CO_2e emission reductions with strengthened GreenPower program



Rate impacts: The rate impacts associated with this mitigation option are summarized in Table F-12 for each sensitivity analysis.

Table F-12. Summary of rate impacts for each ES-10 sensitivity analysis

Option No.	Option Name	2020 Rate Impact (2005 c/kWh)		
		Energy Efficiency	Renewable Energy	Total
ES-10	Strengthening the NC GreenPower program			
1	Original analysis (default assumptions)	0.0000	0.0012	0.0012
2	Original analysis–low levelized cost estimate	0.0000	0.0008	0.0008
3	Original analysis–high levelized cost estimate	0.0000	0.0015	0.0015
4	Original analysis–central levelized cost estimate (2% solar PV set-aside)	0.0000	0.0012	0.0012
5	Original analysis–low levelized cost estimate (2% solar PV set-aside)	0.0000	0.0009	0.0009
6	Original analysis–high levelized cost estimate (2% solar PV set-aside)	0.0000	0.0015	0.0015

2005 c/kWh = cents per kilowatt hour in 2005 dollars.

Key Uncertainties

North Carolina–specific costs of renewable energy investments at penetration levels modeled.

Additional Benefits and Costs

Would help to provide local employment and grow renewable energy use.

Feasibility Issues

Interaction with other options to promote renewable energy needs to be taken into account.

Status of Group Approval

Completed.

Level of Group Support

Unanimous consent.

Barriers to Consensus

None.

Appendix G
Transportation and Land Use
Mitigation Option Recommendations

Summary List of Mitigation Option Recommendations

Option No.	Mitigation Option	GHG Reductions ($MMtCO_2e$)			Net Present Value 2008–2020 (Million $)	Cost-Effective-ness ($/$tCO_2e$)	Level of Support
		2010	2020	Total 2008–2020			
TLU-1a	Land Development Planning	2.6	8.0	58.2	*Net savings*		SMJ
TLU-1b	Multi-Modal Transportation and Promotion (Formerly TLU-2)	3.7	5.8	52.4	–1,300	–25	UC
TLU-3a	Surcharges to Raise Revenue	1.2	2.2	15.7	–1,800	–117	SMJ
TLU-3b	Rebates/ Feebates to Change Fleet Mix	0	< 0.5	2.8	*Not quantified*	–40 to +10	SMJ
TLU-4	Truck Stop Electrification	Included in TLU-8			*Net savings*		UC
TLU-5	Tailpipe GHG Standards	0	8.1	44.5	–1,690	–38	SMJ
TLU-6	Biofuels Bundle	1.9	4.5	35.4	*Not quantified*		UC
TLU-7	Procure Efficient Fleets	Included in TLU-6					UC
TLU-8	Idle Reduction/Elimination Policies	0.1	0.2	2.2	–6	–4	UC
TLU-9	Diesel Retrofits	0.3	2.2	13.5	*Not quantified*		UC
TLU-11	Pay-As-You Drive Insurance	2.3	5.3	42.0	*Expected net savings*		SMJ
TLU-12	Advanced Technology Incentives	*Not quantified*					UC
TLU-13	Buses – Clean Fuels	Included in TLU-6					UC
	SECTOR TOTAL AFTER ADJUSTING FOR OVERLAPS	11.1	25.5	232.3	*Not quantified**		
	REDUCTIONS FROM RECENT ACTIONS	0	0	0	0	0	
	SECTOR TOTAL PLUS RECENT POLICY ACTIONS	11.1	25.5	232.3	*Not quantified*		

UC = unanimous consent (all agree), SMJ = supermajority (at least 80% or more agree). TLU-2 was renamed TLU-1b because if its linkage to TLU-1a. There is no policy option TLU-10, because this catalog option was determined not to be a priority for analysis by the Climate Action Plan Advisory Group.

* Given that several of the recommendations that would produce large reductions do not have associated cost-effectiveness figures, it is not appropriate to attempt to sum the cost-effectiveness figures for those recommendations for which the analysis was possible.

Note that for TLU-5, the estimated greenhouse gas (GHG) emission reduction for each year from 2008 through 2020 was multiplied by the cost-effectiveness value of –$38/ton to estimate cost savings for each year, and then the cost savings for each year was discounted and summed to estimate the net present value. Thus, the cost-effectiveness value of –$38/ton cannot be replicated by dividing the cumulative cost savings by the cumulative emission reduction shown in this table.

TLU-1a. Land Development Planning

Mitigation Option Description

Promote land planning and development that supports conservation of high-quality natural and cultural resources and supports more compact development, and as a result reduces growth in driving and emissions.

Mitigation Option Design

Goals: Support and promote private and public planning and development practices, including infrastructure provision, that reduce the number, length, or travel mode of trips made in North Carolina.

Reduce projected increase in vehicle miles traveled (VMT) by 10% statewide by 2020. (Value was developed after review of targets in several other states, and an assessment by the group of the ability to meet the target.)

Timing: Have policies in place to achieve that VMT goal by 2010.

Parties Involved: Private developers and contractors, local government planning and elected boards, planning staffs for towns and counties, and homeowners.

Implementation Mechanisms

Meeting the goal will require diverse implementation tools. Providing many options, statutory changes, and program assistance for smaller communities will be essential.

Land Use and Development Legislation to Require Adoption of a Growth Plan

- *Each municipality and county shall develop a land use and development plan.*

  The plan should designate planned growth areas and natural resource areas within that jurisdiction and any extraterritorial jurisdiction for a planning horizon of at least 25 years. The land use and development plan should include standards and criteria for conservation area and/or urban service area designations to accommodate a minimum 20-year growth forecast agreed upon by the each county and municipality; establish development and conservation goals; recognize important natural and human resources; and, express appropriate policies, practices and strategies to implement these goals. Local planning programs should include appropriate public involvement processes to achieve consensus on the development and conservation vision for the community.

- *Require and support integration of transportation with land use plans.*

  Maryland, Minnesota, and Denver, Colorado, as well as the nonprofit Triangle Land Conservancy have developed “greenprints” of areas that have old-growth forests, productive agricultural lands, water supply watersheds, historic sites, or other critical and irreplaceable resources. Adding this as a required element of all transportation plans would be a simple and meaningful step that would greatly enhance the effect and benefits of N.C. General Statute

136-66.2 without requiring new zoning or regulatory powers. The November 2004 passage of tax increment financing legislation demonstrates that North Carolina can and does make room for new ideas that help achieve economic development goals in concert with infill development objectives. The North Carolina Small Town Economic Development (NCSTEP) initiative created grant funds that are being used in 33 communities to plan for growth and development in a way that will help those communities benefit from growth and minimize negative impacts.

- *Regulatory incentives* such as withholding transportation funds for noncompliance have worked in Tennessee and should be considered in North Carolina as well.

Remove Barriers to Smart Growth

Many states have successfully implemented a variety of tools that are unavailable to North Carolina municipalities and counties due to prohibitions imposed by North Carolina statutes or constitution. Modify statutes to permit adequate public facilities ordinances, transfer of development rights programs, and development impact fees to improve the ability of local governments to control their own destinies.

Related Policies/Programs in Place

Development of a coordinated transportation system and provisions for streets and highways in and around municipalities.[1]

- The North Carolina Department of Transportation (NCDOT) may participate in the development and adoption of a transportation plan or updated transportation plan when all local governments within the area covered by the transportation plan have adopted land development plans within the previous 5 years.
- The NCDOT may participate in the development of a transportation plan if all the municipalities and counties within the area covered by the transportation plan are in the process of developing a land development plan.
- The NCDOT may not adopt or update a transportation plan until a local land development plan has been adopted. A qualifying land development plan may be a comprehensive plan, land use plan, master plan, strategic plan, or any type of plan or policy document that expresses a jurisdiction's goals and objectives for the development of land within that jurisdiction.
- At the request of the local jurisdiction, the NCDOT may review and provide comments on the plan but shall not provide approval of the land development plan.

Coastal Area Management Act,[2] **Cooperative State-Local Program.**[3]

This Article establishes a cooperative program of coastal area management between local and state governments.

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[1] See in § 136-66.2.

[2] See § 113A-100.

[3] See § 113A-101.

- Local government shall have the initiative for planning.
- State government shall establish areas of environmental concern.
- With regard to planning, state government shall act primarily in a supportive standard-setting and review capacity, except where local governments do not elect to exercise their initiative. Enforcement shall be a concurrent state–local responsibility.
- A wide variety of other state-, regional-, and local-level planning and design programs, requirements, and efforts.

Type(s) of GHG Reductions

Mainly carbon dioxide (CO_2), small amounts of others.[4]

Estimated GHG Reductions and Costs (or Cost Savings)

GHG (greenhouse gas) Reduction Potential in 2010, 2020 (million metric tons of carbon dioxide equivalent [$MMtCO_2e$]): 2.6, 8.0.

Cost-Effectiveness: Expected net savings.

Data Sources:

VMT impacts—A wide variety of literature finds that integrated transportation and land use planning can substantially reduce VMT[5] and its attendant emissions. The appropriate percentage reduction depends on the scale at which policies are applied.[6] Given the methodology used here, a 30% reduction in VMT at the level of an individual development/neighborhood is an appropriate value. This is conservatively below the reductions of 50% and higher that have been empirically observed in neighborhoods planned to allow multi-modal access and compact, mixed-use development.[7]

Costs—A wide variety of literature finds that integrated transportation and land use planning produces net savings on total costs of buildings + land + infrastructure + transportation. Some portions of that total cost may be higher. A preponderance of literature suggests net savings overall.[8] A National Academy of Sciences/Transportation Research Board review found

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[4] The vast majority of the reductions from TLU options will be CO_2 from reduced fuel consumption. We note "and small amounts of others" given the reductions in other GHGs that would accompany the reduction in combustion, such as NO_2.

[5] US EPA, *Our Built and Natural Environments: A Technical Review of the Interactions Between Land Use, Transportation, and Environmental Quality*, 2001. http://www.epa.gov/dced/built.htm

[6] US EPA, *Guidance: Improving Air Quality Through Land Use Activities* (EPA 420-R-01-001, January 2001), and US EPA, *Comparing Methodologies to Assess Transportation and Air Quality Impacts of Brownfields and Infill Development* (EPA-231-R-01-001, August 2001).

[7] Cambridge Systematics, Inc., *Transportation Impacts of Smart Growth and Comprehensive Planning Initiatives: Final Report*, prepared for National Cooperative Highway Research Program, May 2004.

[8] Literature reviews include US EPA, *Our Built and Natural Environments: A Technical Review of the Interactions Between Land Use, Transportation, and Environmental Quality*, 2001; and Burchell et al. in footnote 8.

substantial regional- and state-level infrastructure cost savings from more compact development, as shown in Table G-1.[9]

Table G-1. Burchell findings of savings of compact growth versus current or trend development

Area of Impact	Lexington (Kentucky) and Delaware Estuary	Michigan	South Carolina	New Jersey
Public–Private Capital and Operating Costs				
Infrastructure roads (local)	14.8%–19.7%	12.4%	12%	26%
Utilities (water/sewer)	6.7%–8.2%	13.7%	13%	8%
Housing costs	2.5%–8.4%	6.8%	7%	6%
Cost-revenue impacts	6.9%	3.5%	5%	2%
Land/Natural Habitat Preservation				
Developable land	20.5%–24.2%	15.5%	15%	6%
Agricultural land	18%–29%	17.4%	18%	39%
Frail land	20%–27%	20.9%	22%	17%

We have not attempted to apply these kinds of cost reduction percentages to North Carolina's total infrastructure costs, but even at the low end of the above figures, the total savings would be in the billions.

Quantification Methods:

Apply reductions to light-duty vehicles (LDVs) VMT only:

- 15% of total VMT affected by these policies by 2012; 40% by 2020. So:

  2012 reduction =
  statewide LDV × 15% × 30% = 4% of total statewide heavy-duty vehicles (HDV) + LDV10

  2020 reduction =
  statewide LDV × 40% × 30% = 10% of total statewide HDV + LDV

- Convert to CO_2

Key Assumptions: The given VMT and emissions reductions assume that the planning described in "Implementation Methods" will produce the changed growth patterns necessary to produce the stated goal.

[9] Robert Burchell, et al., *The Costs of Sprawl—Revisited (TCRP Report 39)*, Transportation Research Board/National Research Council/National Academy Press, Washington, DC, 1998.

[10] We express the final result in terms of percentage reduction in LDV + HDV to provide for a common basis of comparison in terms of VMT. Since the ultimate output of interest is CO_2 / GHGs, it may be argued that this intermediate step is unnecessary, but many people find VMT percentage reductions a useful yardstick.

Key Uncertainties

Achieving the given VMT goal depends on a vigorous implementation of the policy initiatives at all levels of government. It is possible that required planning could be done in a way that does not change development patterns and thus does not reduce emissions. Thus, the policy language does not *require* these outcomes.

Additional Benefits and Costs

Benefits from this policy option will increase over longer term implementation.

Benefits include reduced infrastructure costs noted above, avoided health care costs from reduced air pollution and increased walking/biking, and other quality-of-life aspects.

Costs: There will be front-end costs of program development and implementation, and a successful program requires dedicated resources.

Feasibility Issues

None cited.

Status of Group Approval

Approved.

Level of Group Support

Supermajority.

Barriers to Consensus

Philosophical objection to planning.

TLU-1b. Multi-Modal Transportation and Promotion

Mitigation Option Description

Shift passenger transportation mode choice to lower emitting choices. Ensure that transportation is integrated with and appropriately serves land-use development plans (developed under TLU-1a). Implement the North Carolina transportation plan allocation of 13% of state transportation spending to transit.

Mitigation Option Design

Goals:

Implement policies that increase use of public transportation, producing a shift to lower emitting mode choices, by the following policies:

- Improve transit service (frequency, convenience, quality).
- Expand transit infrastructure (rail, bus, bus rapid transit).
- Focus new development on transit-served corridors (transit-oriented development).
- Expand transit marketing and promotion (including tax-free and employer-paid commuter benefits, and parking cash out).
- Expand transportation system management and design, which speeds both transit and other traffic.
- Improve bike and pedestrian infrastructure both as feeders and as stand-alone modes.

Timing:

- Many programs are in place and are therefore immediately expandable or implementable. Enhancement and continuation can begin short-term.
- Infrastructure improvements will take 1–5 years at a minimum.

Parties Involved: NCDOT, regional transportation districts, metropolitan planning organizations, regional planning organizations, other regional authorities (such as Research Triangle Park Rail Transit Authority), municipalities, counties.

Other: None cited.

Implementation Mechanisms

- Aggressively support and aid the creation of Regional Transportation Districts (RTDs). RTDs can sell bonds for capital projects, and member governments can levy taxes for operation and maintenance subject to voter approval.
- Make planning and funding rules more flexible to allow transit operators to provide service to places outside of their municipal jurisdictions.

- Abolish or reduce minimum parking requirements in zoning codes, and allow localities to establish parking maximums.
- Create a best practice guide and recognize developers who adhere to best practice when designing and locating new private and public development.
- Require planning to extend beyond 5 years (20 years recommended) for all systems.
- Create incentives or require the purchase of biodiesel fuel (minimum: B20) as a part of all public bus replacement programs. Conover (NC) has already done so with great results.
- Location of state facilities—Locate state facilities near transit facilities. Where and when appropriate or possible, all state government offices should be located downtown. Similarly, provide transit to serve concentrations of state employees.[11]
- State targeting of infrastructure investments—Legislatively appropriated capital outlay funds, state public revolving loan funds, and other state-funded infrastructure initiatives should be used for projects that encourage walkable and traditional communities and are supportive of transit.
- Make maintenance of infrastructure a priority—Fix it First. Revise any state infrastructure programs for transportation, water, and sewer that fund new systems but not maintenance or upgrades for existing systems.
- Replace "average cost pricing" for utilities services with rate structures that charge full marginal costs for both new infrastructure and for water, sewer, electricity, and telephone service delivery.
- Fund the transportation-related programs in this mitigation option with monies generated by other mitigation options such as feebates and/or gas tax.

Related Policies/Programs in Place

Overall, the North Carolina State Transportation Plan recommends spending 13% of total state transportation funding on transit over the next 25 years.

Statewide Transportation Demand Management Program (TDM)

- NCDOT-Public Transportation Division (PTD) supports the formation and ongoing activities of local TDM programs across the state by funding up to 50% of the cost of administering and marketing the services of the local TDM programs.
- Provide training for the TDM coordinators operating the TDM programs. Currently, there are programs in the Charlotte, Asheville, Triad, Triangle, and Wilmington areas of the state.
- In support of the TDM programs, the state funded, with local areas' support, a ride-matching program that is available statewide which individuals can access through the Internet to find or form carpools or vanpools for their daily commuter trips.
- The state is looking into adding a module to the program that allows individuals to enter trip needs that vary by day of the week instead of the usual Monday-through-Friday work trip.

[11] This is an Executive Order from North Carolina Governor James Holshouser.

The new module would allow part-time workers, workers with variable work schedules, and college students to find rides even though their trips are not regular throughout the week.

Intermodal Transportation Centers

- NCDOT-PTD works with municipalities in the state's larger cities to develop intermodal transportation centers that allow for seamless movement between intercity passenger rail, intercity bus, and city bus services. Currently, Greensboro has an intermodal center in operation that spurred double-digit increases in ridership on the city's bus system and the intercity bus operator after it opened. Rocky Mount has a successful intermodal center in operation. Additional projects are being developed in the following areas: Charlotte, Durham, Fayetteville, Greenville, Raleigh, Wilmington, and Winston-Salem.
- The state assists the municipalities in getting Federal Transit Administration (FTA) funding, provides a 10% match to the 80% FTA funding, and participates in the planning, land acquisition, and design processes leading to construction of the centers.

Technology on Transit Vehicles and Facilities

- NCDOT-PTD supports the installation of new technologies on transit buses and in-transit facilities that make transit services safer and more efficient and that provide a higher level of information on the services for riders and potential riders. The state funds 90% of the cost of the technologies. Examples of such technologies include installation of cameras on buses (safety), real-time transit service information signage at transit facilities (more information), compatible electronic fare boxes for systems in one region (ease of transit systems use), and installation of automatic vehicle location (AVL)/global positioning systems (GPS) systems on buses (more efficient operation and more information to passengers).

Type(s) of GHG Reductions

Mainly CO_2, small amounts of others.

Estimated GHG Savings and Costs per $MtCO_2e$

GHG Reduction Potential in 2010, 2020 ($MMtCO_2e$): 3.7, 5.8.

Cost-Effectiveness: Expected net savings.

Data Sources:

Reductions from transit improvements: transit economics literature.[12]

Reductions from TDM and transit promotion: TDM literature.[13]

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[12] See Brian E. McCollom and Richard Pratt. 2004. "Transit Pricing and Fares." TCRP Report 95. Washington, DC: Transportation Review Board; and Robert Cervero, 1990. "Transit Pricing Research." Transportation 17(2):117–140; and Victoria Transport Policy Institute, "Public Transit Improvements," in *TDM Encyclopedia*, 2005.

[13] Including ICF Consulting, "Strategies for Increasing the Effectiveness of Commuter Benefits Programs: Transit Cooperative Research Program Report 87," Transportation Research Board, Washington, DC, 2003; ICF Consulting, "Analyzing the Effectiveness of Commuter Benefits Programs: Transit Cooperative Research Program Report 107," Transportation Research Board, Washington, DC, 2005; and ICF Consulting, "Commuter Connections Strategic Review," report to the Maryland Department of Transportation Office of Planning and Capital Programming, November 7, 2004.

Costs: Both the above, and transit cost-benefit analysis guidance.[14]

Quantification Methods:

Emissions reductions

Apply reductions to urban LDV VMT only.

- Reductions from transit improvements:

2%	Current passenger miles traveled share for transit trips
25%	Percentage decrease in transit fares
80%	Percentage increase in service
0.4	Elasticity of transit demand with respect to price
0.8	Elasticity of transit demand with respect to service
2.20%	Calculate expected percent reduction in VMT (based on fare decrease)
3.28%	Calculate expected percent reduction in VMT (based on service increase)

  - 2012 reduction = 2.79% of total statewide HDV + LDV
  - 2020 reduction = 2.76% of total statewide HDV + LDV
- Reductions from TDM and transit promotion:

50%	Multiply urban LDV VMT by the percent of travel that can be reached by TDM
12%	Effectiveness of TDM measures for reducing VMT (through 2012)
20%	Effectiveness of TDM measures for reducing VMT (through 2020)
4%	Calculate expected percent reduction in commute VMT through 2012
6%	Calculate expected percent reduction in commute VMT through 2020

  - 2012 reduction = 3.05% of total statewide HDV + LDV
  - 2020 reduction = 5.04% of total statewide HDV + LDV
- Add reductions from multi-modal investments + reductions from TDM and transit promotion.
- Convert to CO_2.

Cost-Effectiveness:

The cost-effectiveness of investments in transit and transit promotion will vary depending on how those investments are made, and the Option language gives the state and its constituents wide flexibility in making those investments. A given investment in transit and/or transit promotion may or not produce net benefits, so while this process needs to make general policy recommendations, it will remain the responsibility of the state and its constituents to maximize the cost-effectiveness of investments made.

For the purposes of this analysis, we ask whether those types of investments are *likely* to produce net costs or net savings. A wide variety of empirical experience suggests that the policies and

[14] "ECONorthwest, Estimating the Benefits and Costs of Public Transit Projects: A Guidebook for Practitioners," Transit Cooperative Research Program Report 78, Transportation Research Board/National Research Council/ National Academy Press, Washington, DC, 2002.

investments listed in the Option Design and Implementation Mechanisms sections are likely to produce substantial net savings, as in the following four examples.

1. *Transit investments generally*

   Nationally, transit produces net economic returns on investment: "For every $10 million invested, over $15 million is saved in transportation costs to both highway and transit users. These costs include operating costs, fuel costs, and congestion costs." These are in addition to the ancillary benefits summarized below [see "Additional Benefits and Costs"].[15]

   At a high level, then, the benefits of the proposed investment in transit can be estimated as follows:

NCDOT budget:	$2.5 billion/year
13%	$325,000,000/year
× 1.5 savings multiplier	$487,500,000/year in savings
–cost of investment	$325,000,000/year
Total benefits	$162,500,000/year

   This substantial return on investment is the basis for the cost savings number reported in the opening table to this Appendix, the Summary List of Mitigation Option Recommendations (hereafter, Summary List table). Without knowing more about how North Carolina will make its transit investments, it is not possible to do a finer-grained analysis. However, the following examples suggest that the 1.5× savings multiplier may be conservative.

2. *Transit fare initiatives*

   Unlimited access transit at the University of California-Los Angeles costs $810,000/year and has total benefits of $3,250,000/year,[16] a return on investment of more than 4×. Similar programs at other universities show similar results.[17] The many educational institutions in North Carolina could see similar savings.

   Universities are, in some senses, unique institutions, but the general types of challenges (especially demand for and costs of providing parking) and the types of benefits enjoyed in response to commute benefits programs are equally available to businesses. A report on this topic notes:

   > "Eco Passes also offer significant advantages for employers who offer free parking to all commuters, because those who shift from driving to transit will reduce the demand for employer-paid parking spaces. A survey of Silicon Valley commuters whose employers offer Eco Passes found that the solo-driver share fell from 76% before the passes were offered to 60% afterward. The transit mode share for commuting increased from 11% to 27%. These mode shifts reduced commuter parking demand by approximately 19%.

[15] Cambridge Systematics, Inc., Public Transportation and the Nation's Economy: A Quantitative Analysis of Public Transportation's Economic Impact, 1999.l

[16] Jeffrey Brown, Daniel Hess, and Donald Shoup, "Fare-Free Public Transit at Universities: An Evaluation," Journal of Planning Education and Research (23:69–82), 2003.

[17] Jeffrey Brown, Daniel Hess & Donald Shoup, "Unlimited Access," *Transportation* 28:233–267, Kluwer, 2001.

> "Given the high cost of constructing parking spaces in the Silicon Valley, each $1 per year spent to buy Eco Passes can save between $23 and $333 on the capital cost of required parking spaces."[18]

3. *Transit and non-SOV (single-occupancy vehicle) options information and promotion*

   Per public dollar, a transportation management organization (TMO) can accommodate seven times as many commuters as new highway investment.[19]

4. *TDM investments generally on the basis of avoided driving*

   This policy is estimated to reduce VMT by 3,317,688,733 in 2012, and 3,970,779,011 in 2020. The current U.S. Internal Revenue Service–estimated cost of driving a mile in a personal vehicle is $0.485. At that rate, total savings will be

	2010	**2020 (constant $)**
VMT reduced	$3,317,688,733	$3,970,779,011
@ $0.485 / VMT, Avoided costs =	$1.6 billion	$1.9 billion
–Cost of investment	$325,000,000	$325,000,000
Net savings	$1.2 billion	$1.6 billion

That is, the estimated $162,500,000/year in total savings used for the Summary List table is very conservative.

Key Assumptions: Portions of TLU-1b support TLU-1a. The quantifications for TLU-1b focus on the role of transit, transit promotion, and related initiatives. TLU-1a and -1b are labeled as (a) and (b) to emphasize their interdependent nature. We assume that they are implemented in concert to maximize effectiveness. Nonetheless, not all benefits are dependent on joint implementation. To use the Eco Pass example noted above, Silicon Valley has little land use planning of the type called for in TLU-1a, but Eco Passes still have substantial emissions reductions and other benefits. See "Feasibility Issues" for additional discussion.

Key Uncertainties

None cited.

Additional Benefits and Costs

There is a broad literature on the role of transit as a part of a modern economy and as a key contributor to creating and maintaining certain aspects of quality of life and a healthy, efficient economy. Overarching reviews of that literature are done only periodically, one of the most comprehensive being Cambridge Systematics (CS), Inc., *Public Transportation and the Nation's Economy: A Quantitative Analysis of Public Transportation's Economic Impact*, 1999. It lists the following additional types of benefits from transit investments. We give this list, and cite CS's bottom line estimate of transportation benefits above, not to suggest that North Carolina would necessarily see the same multipliers, but to support the above finding of a substantial savings multiplier from transit investments:

[18] Ibid., p. 260.

[19] Minnesota Department of Transportation, Modal Options Identify Project, "Measurement and Evaluation," 2006

- “Transit capital investment is a significant source of job creation. This analysis indicates that in the year following the investment, 314 jobs are created for each $10 million invested in transit capital funding.
- “Transit operations spending provides a direct infusion to the local economy. Over 570 jobs are created for each $10 million invested in the short run.
- “Businesses would realize a gain in sales three times the public sector investment in transit capital; a $10 million investment results in a $30 million gain in sales.
- “Businesses benefit as well from transit operations spending, with a $32 million increase in business sales for each $10 million in transit operations spending.
- “Business output and personal income are positively impacted by transit investment, growing rapidly over time. These transportation user impacts create savings to business operations and increase the overall efficiency of the economy, positively affecting business sales and household incomes. A sustained program of transit capital investment will generate an increase of $2 million in business output and $0.8 million in personal income for each $10 million in the short run (during year one). In the long term (during year 20), these benefits increase to $31 million and $18 million for business output and personal income, respectively.
- “Transit capital and operating investment generates personal income and business profits that produce positive fiscal impacts. On average, a typical state/local government could realize a 4% to 16% gain in revenues due to the increases in income and employment generated by investments in transit.
- “Additional economic benefits which would improve the assessment of transit’s economic impact are difficult to quantify and require a different analytical methodology from that employed in this report. They include “quality of life” benefits, changes in land use, social welfare benefits, and reductions in the cost of other public sector functions.
- “The findings of this report complement studies of local economic impacts, which carry a positive message that builds upon the body of evidence that shows transit is a sound public investment. Local studies have shown benefit/cost ratios as high as 9 to 1.”

Feasibility Issues

Like any class of investment, the fact that, empirically and on average, the investment produces net returns does not guarantee that a given investment will do so. Transit investment and operation and transit promotion need to be tailored to the communities they serve, *and* be well planned, implemented, and run to produce the maximum return on investment (ROI). Emphasizing one aspect of TLU-1a or TLU-1b at the expense of another will reduce potential ROI and available emissions reductions.

Status of Group Approval

Approved.

Level of Group Support

Unanimous consent.

Barriers to Consensus

None.

TLU-3a. Surcharges to Raise Revenue

Mitigation Option Description

Vary motor vehicle registration fees by vehicle emissions to provide a surcharge on higher emitting vehicles.

Mitigation Option Design

Goals:

- To raise funds for State of North Carolina to support transportation-related projects that reduce GHG.
- To raise funds through a mechanism that is directly tied to a significant source of GHG emissions from cars and trucks. It is not envisioned that the scale of the surcharge would affect the fleet mix; the goal of this policy is revenue raising that is tied to emissions.

Timing: Should be implemented as soon as possible.

Parties Involved:

- Department of Motor Vehicles (DMV).
- Agencies that distribute and spend revenue.
- Consumers

Other: None cited.

Implementation Mechanisms

Legislation-directed "surcharges."

- The Legislature would establish a surcharge schedule. One possible example follows:

  In light-duty vehicles, the appropriate emissions/efficiency factor is identified in Table G-2. This can be done by a DMV computer. This factor is based on the vehicle's Green Vehicle Guide rating, as published by the U.S. Environmental Protection Agency (US EPA).[20] Incorporating the vehicle's Green Vehicle Guide rating, accounts for both fuel economy and emissions.

[20] See http//www.epa.gov/greenvehicles

Table G-2. Emissions/efficiency factor for light-duty vehicles

Combined Score From EPA Green Vehicle Guide	Emissions/Efficiency Factor
19-20	10,000
17-18	9,000
15-16	8,000
13-14	7,000
11-12	6,000
9-10	5,000
7-8	4,000
5-6	3,000
3-4	2,000
<3	1,000

To calculate the surcharge, VMT is divided by the emissions/efficiency factor, as shown in Table G-3.

Table G-3. Surcharge examples

Vehicle	Vehicle Miles Traveled	Combined Score from EPA Green Vehicle Guide	Factor from Table G-2	Fee (VMT/Factor)
Toyota Prius	15,000	20	10,000	$1.50
Volkswagen Jetta Diesel, Manual	21,000	13	7,000	$3.00
Chevy Cavalier	49,000	14	7,000	$7.00
Toyota Land Cruiser	15,000	2	1,000	$15.00

- Generally, the surcharge design needs to be simple, minimize the number of pivot points, be well-documented, and be designed to maximize not minimize consumer attention.
- During the past two legislative sessions, variations of a motor vehicle surcharge were introduced; these could be drawn on for more detailed policy language.

Mobile Source Emission Reduction Program

Establishes variable motor vehicle registration fees based on a vehicle's pollution and fuel economy score to generate funds for public and private sector use of alternative fuel and advanced transportation technologies. Funds would be distributed through the State Energy Office for transportation projects that support clean air renewable energy objectives. The committee proposed a substitute to set vehicle surcharges from $2 to $14 annually.

The above description implies an earmarking of funds so that they may be used only for activities that reduce GHG from travel; that provision may be made explicit.

Design and implementation of this option should also account for regional equity. Because urban areas generally offer economies of scope and scale in VMT reduction, it is possible that a disproportionate amount of funds could return to urban areas, although rural drivers

will pay the surcharges as well. Program design and grant criteria should take into account the policy goal of returning funds to contributing areas. There are numerous opportunities to reduce VMT and emissions in rural areas as well, from telework centers to appropriately designed transit.

Related Policies/Programs in Place

None.

Type(s) of GHG Reductions

CO_2.

Estimated GHG Reductions and Costs (or Cost Savings)

Emissions reductions

- 5.1 million North Carolina LDV registrations per year at an average of $7.25 per vehicle would produce $37 million per year for programs to reduce emissions from travel.
- The most efficient regionally funded regional commuter programs can reduce VMT for a cost of $0.02/mile. Most regional commuter programs cost more per mile. On the other hand, few are as well funded as this proposal, and there are almost certainly economies of scale and scope.
- $37 million per year times $0.02 per mile equals 1,850,000,000 VMT = 2% of total statewide VMT; 3% of total urban light-duty vehicle LDV VMT.
- This achieves roughly half the amount of emission reductions produced by the "transit promotion and TDM" portion of TLU-1b: 1.0 $MMtCO_2e$ in 2010; 1.9 $MMtCO_2e$ in 2020.

This surcharge option is envisioned as likely to fund the types of transit promotion activities described in TLU-1b. As such, there are two quantification options:

- TLU-1b actions are envisioned to be funded out of the increased portions of the state transportation budget. If recommended increases are not available from the current transportation budget, this surcharge mechanism would be used. In this case, TLU-3a GHG reductions would not be reported separately.
- If TLU-1b options are funded at the level recommended in the state transportation plan, then the reductions achieved by implementing this surcharge option would be additive and reported separately.

For this analysis, we assume the second, additive option.

Costs/cost savings

If, as in the above example, revenue is used to fund multi-modal options promotion that reduces VMT, then we can estimate net benefits as show in Table G-4.

Table G-4. Estimated benefits: using surcharge revenues to fund multi-modal options

	2010	2020 (constant $)
VMT reduced	$1,850,000,000	$1,850,000,000
@ $0.485 / VMT, Avoided costs =	$ 897,250,000	$ 897,250,000
–Cost of investment	$ 37,000,000	$ 37,000,000
Net savings	$ 860,250,000	$ 860,250,000

If, in an effort to be conservative, we limit the savings to the 7× savings multiplier found in a study for Minnesota DOT, [21] then the net benefits fall, as indicated in Table G-5.

Table G-5. Conservative estimate of benefits (used in Summary List table)

	2010	2020 (constant $)
Cost of investment	$37,000,000	$37,000,000
Avoided cost @ 7x investment	$259,000,000	$259,000,000
Net savings	$222,000,000	$222,000,000

We use this lower number in the Summary List table.

Data Sources: VMT reductions/$ from:

ICF, *Commuter Connections Strategic Review: Final Report*, for Maryland Department of Transportation, Office of Planning and Capital Programming, November 7, 2004.

Minnesota Department of Transportation, Modal Options Identify Project, "Measurement and Evaluation," 2006

Quantification Methods: Above.

Key Assumptions: $2–$14 surcharge has no direct effect on behavior. All reductions come from supporting other programs.

Key Uncertainties

Which programs would be funded with these monies. Program could be designed as an auction or bidding in order to fund the most cost-effective projects.

Additional Benefits and Costs

None cited.

Feasibility Issues

None cited.

[21] Minnesota Department of Transportation, Modal Options Identify Project, "Measurement and Evaluation," 2006

Status of Group Approval

Approved.

Level of Group Support

Supermajority.

Barriers to Consensus

Concern over effect on consumer choice.

TLU–3b. Rebates/Feebates to Change Fleet Mix

Mitigation Option Description

Rebates/feebates charge or rebate a sliding scale of fees and rebates for new light-duty vehicles based on their emissions of GHGs, fuel consumption, and/or other measures of a vehicle's environmental impacts. This provides an incentive for manufacturers to sell cost-effective efficiency technologies, and for consumers to buy lower-emitting vehicles.

Mitigation Option Design

Goals: To reduce overall GHG emissions from new automobiles purchased in the state.

- By having price signals reflect emissions levels and thus have emissions level more directly enter buying decisions.
- By sending a signal to manufacturers to produce increasingly low-emitting vehicles for the market.
- By creating a dedicated revenue stream for promotion of low-emitting or no-emitting GHG transportation alternatives, e.g., hybrid tax credits, transit infrastructure.

Timing: Should be implemented as soon as possible.

Parties Involved: All new light-duty vehicles registered in North Carolina, consumers.

Other: None cited.

Implementation Mechanisms

Legislation-directed "rebates/feebates."

- The simplest is to set the fee or the rebate in proportion to the amount of fuel consumed by the vehicle per mile driven. Specify the rate (in dollars per mile) and the "pivot point" between fees and rebates. The location of this pivot point will determine the net revenue flow.
- Emissions could be considered relative to other vehicles within each class or across classes based on their design variations.
- The rebate/feebate could be set as a multiplier for an excise tax so that the fee or rebate is determined not only by the emissions rate of the vehicle but by its price as well.
- Generally the rebate/feebate design needs to be simple, minimize the number of pivot points, be well-documented, and be designed to maximize consumer attention.

Related Policies/Programs in Place

Feebates have been proposed in many forms over the last 15 years but have not yet been implemented in the United States. Rebate/feebate programs would work on two levels. First, the feebates would directly affect consumer choices for vehicle purchases as a result of the financial incentives. Second, the feebates could indirectly affect the types of vehicles and technologies

that manufacturers offer. While feebate proposals have been described in academic studies, there has been no implementation of a full feebate program to date in the United States. While there is a "gas guzzler tax" and tax incentives for hybrid vehicle purchases, there is not yet any history of an on-the-ground example of an implemented feebate program.

Existing analysis shows that 90% of the benefits of feebate programs are likely to arise from the manufacturing response, as manufacturers change the technology mix in the fleet, rather than the consumer response, in which consumers change the mix of purchasing decisions within the current for-sale fleet. Manufacturers are also unlikely to substantially change their technology mix in response to a single state feebate program. These studies have spurred an interest in multi-state feebate programs as a way to increase the increase the size of the affected market and, thus, the incentive for manufacturers to shift technology mix. This policy option assumes only a North Carolina–level policy.

Type(s) of GHG Reductions

Mainly CO_2.

Estimated GHG Reductions and Costs (or Cost Savings)

Data Sources:

- CCS quantifications for feebates option for Arizona.
- Marbek Resource Consultants in association with Resources for the Future and DesRosiers Automotive Consultants, *Development of Options for a Vehicle Feebate in Canada*, Final Report, October 13, 2005.

Quantification Methods:

Impacts

Attempts have been made recently to estimate the GHG emissions reduction potential from individual state feebate programs, including programs proposed for the states of Arizona and California. A rough extrapolation to North Carolina suggests that a stand-alone feebate program is unlikely to produce reductions of more than 0.5 $MMtCO_2e$ in 2020.

These recent estimates of the potential impacts of individual state programs are contingent upon assumptions and analytical methods that have not undergone thorough peer review. Therefore, the results of these analyses are preliminary and should be interpreted with caution. Further analysis and study of the potential benefits and costs of individual state and multi-state feebate programs would greatly increase confidence in projected results.

Costs

A wide variety of economics literature finds that vehicle buyers do not buy all the efficiency technology that is cost-effective, taking into account the net present value of both the fuel savings and the additional technology cost. Feebate analyses, the most recent of which is cited above, find that the fuel savings that result from a feebate program would pay for additional costs, producing net cost savings:

> "The reduction in consumer surplus is more than compensated for by unvalued fuel savings that are realized. The benefits are positive for all rates up to $1,000 but marginal costs begin to outweigh benefits

between $500 and $1,000. Adopting two or more classes reduces the benefits significantly while creating a relative subsidy for larger vehicles."

As a result: Net benefits range from $40 per ton for a low feebate, to $10 per ton for a high feebate.

"If it is assumed that consumers already fully value fuel savings, then there are no unvalued fuel savings and the costs are in the range of $10 per ton."

Key Assumptions: That the North Carolina program is stand-alone.

Key Uncertainties

Until the United States has more experience with feebates, responses on both the consumer and producer sides are uncertain. In a single-state program, most of the response would come from the consumer side, because the production mix is unlikely to change substantially in response to demand changes a single-state market.

Additional Benefits and Costs

None cited.

Feasibility Issues

None cited.

Status of Group Approval

Approved.

Level of Group Support

Supermajority.

Barriers to Consensus

Concern over effect on consumer choice.

TLU-4. Truck Stop (and Places Where Trucks Stop) Electrification

Mitigation Option Description

Reduce idling-induced emissions from heavy-duty diesel trucks by providing electrical hookups to power heating, cooling, and other needs while stopped.

Mitigation Option Design

Goals:

- To reduce the engine emissions from diesel trucks (typically, tractor trailers) by allowing truck drivers to "plug in" engine heaters, heating, ventilation, and air conditioning (HVAC), and other electrical devices
- To use truck stop electrification (TSE) to support idle reduction/elimination (IR/E) policies.

Timing: Conduct analysis of existing pilot projects at major truck stops on Interstate highways (principally, I-40 and I-85) and initiate other efforts at other places where truck traffic is high. Then, progress to include all major truck stops statewide with at least one multi-unit electrified stop in each of the 17 urban areas in North Carolina.

Parties Involved: All long-haul truck drivers of semi-tractor trailers, all combination trailers.

USDOT requires all truck drivers to rest for at least 10 continuous hours after an 11-hour driving stint within every 24-hour day and 34 continuous hours once per week.

Other: Note that truck stop electrification may entail all off-board systems (often called shore power based on their use at marinas) or some on-board/some off-board systems. The all off-board option may be owned by the proprietor of the truck stop. On-board equipment is owned by the driver/owner or trucking company.

Implementation Mechanisms

Third-party vendors, truck stop owners, and trucking companies will play key roles in the advancement and absorption rate of this option. A state-shared responsibility for funding and promotion, coupled with a strong, phased-in idle reduction/elimination policy, is one possible approach. Acquiring feedback during the initial projects (some of which are already in place in North Carolina) and modifying the program accordingly will be critical as well.

Related Policies/Programs in Place

North Carolina has several TSE pilots in place. While programs are in discussion, there are no policies or laws to enforce participation. TSE is typically discussed during anti-idling legislation. Pennsylvania, Oregon, and Washington[22] each appear to have an existing program, as do certain cities, counties, or other such jurisdictions.

[22] See http://www.treehugger.com/files/2005/10/truck_stop_elec.php

Type(s) of GHG Reductions

CO_2, black carbon.

Estimated GHG Reductions and Costs (or Cost Savings)

This mitigation option calls for a pilot program but does not set penetration or adoption goals. As a result, we quantify cost-effectiveness, but assume that reductions are part of reductions achieved under TLU-8.

Data Sources:

Thomas L. Perrot, "Truck Stop Electrification as a Long-Haul Tractor Idling Alternative," ANTARES Group Inc., presented at the Transportation Research Board Annual Meeting, 2004.

Quantification Methods:

Perrot summarizes the results of a New York Interstate 90 Truck Stop Electrification (TSE) Demonstration study:

> "$1.70 (fuel) + $0.92 (maintenance) – $1.50 (cost for TSE service) = $1.12 (net savings per hour of use [to the trucker])"

The key variable in that equation is the full cost of the TSE service. Perrot concludes:

> "A TSE shore power facility installation can be engineered and installed at a cost that will provide a simple payback to the investor/owner in three years or less based solely on electrical supply. Revenue from other value-added services, such as cable TV, telephone, and Internet service, will reduce the simple payback period."

Numerous other pilot studies are underway,[23] but based on the experience summarized here, we feel comfortable with a "net savings" forecast of costs.

Key Assumptions: See TLU-8.

"Net savings" and "a 3-year payback" do not necessarily mean substantial market penetration without public–private partnership. For example, EPA has a loan program for truckers to acquire fuel efficiency technologies; the technologies pay for themselves over time, plus reduce emissions, but due to a lack of market offerings, a public–private loan approach is being taken. Thus the mitigation option calls for additional pilot projects to test appropriate approaches for North Carolina.

Key Uncertainties

None cited.

Additional Benefits and Costs

None cited.

[23] http://www.epa.gov/smartway/idle-demo.htm

Feasibility Issues

None cited.

Status of Group Approval

Approved.

Level of Group Support

Unanimous consent.

Barriers to Consensus

None.

TLU-5. Tailpipe GHG Standards

Mitigation Option Description

Adopt the State Clean Car Program to reduce emissions of GHGs from vehicle operation.[24]

Mitigation Option Design

Goals: Use California Clean Car standards for cars and light trucks to reduce GHG emissions. California standards require GHG emissions reductions of about 30% from new vehicles phased in from 2009 to 2016 through a variety of means.[25] Other Clean Car Program elements include standards requiring reductions in smog- and soot-forming pollutants and promoting introduction of very-low-emitting technologies into new vehicles.

Timing: The General Assembly could enact legislation in 2009 at the earliest unless tied to a 2007 bill carried over to 2008 so that North Carolina can implement the California standards.[26]

Parties Involved: Automobile and light truck manufacturers, car and light truck dealers, consumers.

Implementation Mechanisms

Institute a regulatory program beginning with vehicle model year 2011.

Type(s) of GHG Benefit(s)

In this option, principally CO_2 reductions are felt with some reduction also in N_2O, CH_4, and refrigerant losses.[27]

Related Policies/Programs in Place

Federal regulation of tailpipe emissions.

Estimated GHG Savings and Costs Per Ton

GHG Reduction Potential in 2010, 2020 ($MMtCO_2e$): 0, 8.09.

Cost-Effectiveness: Net savings of $38–$117/ton.

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[24] Also known as the "Pavley" standards (after Assemblywoman Fran Pavley who introduced the legislation) or "California GHG emission standards."

[25] For detailed information see: http://www.arb.ca.gov/cc/ccms/ccms.htm

[26] The California standards currently are being litigated, and timing may be affected as a result. Recent court decisions have found that CO2 can be a pollutant under the Clean Air Act (CAA). Many observers see this as clearing the way for the required EPA waiver under the CAA.

[27] See: http://www.arb.ca.gov/cc/factsheets/cc_isor.pdf. Note that the California standards apply not only to emissions from combustion, but also to other sources of GHGs in cars, such as refrigerants from air conditioning.

Data Sources: The Center for Climate Strategies (CCS), Draft North Carolina Greenhouse Gas Inventory and Reference Case Projections, 2006.

- Mary Braun, Tony Dutzik, Jeanne Bassett, "A Blueprint for Action: Policy Options to Reduce New Mexico's Contribution to Global Warming," New Mexico Public Interest Research Group (PIRG) Education Fund, Spring 2006.
- Elizabeth Ridlington, Tony Dutzik, and Christopher Phelps, "Cars and Global Warming: Policy Options to Reduce Connecticut's Global Warming Pollution from Cars and Light Trucks," Spring 2005.

Quantification Methods:

Emissions reductions

CCS compared results from New England states, California, and a PIRG model that were obtained using comparable modeling methods. The CCS found that while all three modeling efforts were valid, reasonable, and comparable, some of the PIRG model assumptions and methods were relatively conservative, while the California and New England modeling results were relatively optimistic. CCS further refined the PIRG model results consistent with a middle-range scenario that produced results less conservative than the PIRG results and less optimistic than the California and New England results. While PIRG projected a 13.7% reduction in light-duty vehicle emissions with this policy for Arizona, a CCS refinement estimated a 15.5% reduction in emissions for Arizona. CCS applied this same refined percentage reduction in emissions to the Climate Action Plan Advisory Group (CAPAG) reference case for North Carolina.

Costs

A review of past $/ton estimates prepared for the Pavley-type regulation for California Air Resources Board (CARB), Northeast States for Coordinated Air Use Management (NESCAUM), and CCS can produce an estimate of up to $117 saved for each metric ton of CO_2e reduced.

Other estimates predict lower net savings, or net costs. The CARB estimates that the cost of compliance in a new vehicle in model year 2016 would be approximately $1,000. To determine the net impact on consumers, CARB calculated the increase in monthly loan payments and the savings from reduced fuel consumption. CARB forecasts that consumers would achieve a net savings, starting at the time of purchase, of approximately $3.50 to $7.00/month. Extrapolating this estimate of net savings to the North Carolina vehicle fleet would require an estimate of the North Carolina vehicle fleet in 2020, and North Carolina does not make such a forecast. There was a total of 5,097,000 light-duty vehicles in North Carolina in 2006. If all of those turn over by 2020, and each saves $5/month, then net benefits would be:

(5,097,000 vehicles × $60/vehicle/year) / 8.1 tons = $37.80 $/ton savings.

In contrast, automobile manufacturers estimate that the California standards would cost around $3,000 per vehicle and calculated that savings on fuel would offset less than half of that cost for consumers.

In an effort to be conservative, we selected a cost-effectiveness value of –$38. More than 10 other states have adopted the California standards. Among other factors that support the use of a

savings estimate toward the higher end of the range, manufacturers should realize economies of scale that would lower manufacturing costs as additional states adopt the standards.

Key Assumptions:

- The three modeling efforts have established a valid and reasonable method of projecting GHG emissions reductions from this policy.
- The CCS comparison of the three modeling methods provides some independent professional validation of the models and their results.
- The key assumption of the emissions reduction projected by CCS is that the most likely scenario for emissions reductions is one that would fall between the more conservative scenario projected by the PIRG model and the more optimistic scenario projected by the California and the New England models.

Key Uncertainties

California's law is being litigated. North Carolina's ability to adopt California's standard depends on EPA's issuing California a waiver under the Clean Air Act.

Once enacted, benefits depend on fleet turnover rates for light-duty vehicles and future patterns of consumer purchase choices between passenger cars and light-duty trucks (e.g., sport utility vehicles [SUVs]).

Additional Benefits and Costs

Reductions in criteria air pollutants.

Feasibility Issues

None cited.

Status of Group Approval

Approved.

Level of Group Support

Supermajority.

Barriers to Consensus

Concern over potential costs.

TLU-6. Biofuels Bundle

Mitigation Option Description

This option seeks to increase market penetration of biofuels in North Carolina by a mixture of policies (voluntary and/or mandatory) to achieve feasible goals—offsetting fossil fuel use (gasoline) with production and use of starch-based and cellulosic ethanol.

Replacing gasoline with ethanol can reduce GHGs to the extent that the ethanol is produced with lower GHG content. Biodiesel has a lower GHG content than fossil diesel, so using biodiesel instead of fossil diesel reduces GHG emissions.

This option is linked with policy options AFW-2, Biodiesel Production, and AFW-6, Policies to Promote Ethanol Production. This option seeks to develop the demand for biofuels, whether produced locally or out-of-state. (Options AFW-2 and AFW-6 pursue the GHG benefits achievable beyond TLU options by promoting in-state production of ethanol and biodiesel using feedstocks and production methods with greater GHG benefits than the likely business-as-usual national market production methods, e.g., conventional starch-based ethanol.)

Mitigation Option Design

The goals for this policy should be phased in utilizing biofuels to replace the specified percentages of gasoline and diesel consumed for transportation throughout North Carolina by the specified years, as shown under Goal Levels, below. The goals of this policy can be achieved through a combination of renewable fuels standards, financial incentives, outreach, and market-based mechanisms.

Goal Levels and Timing:

- The goal levels and timing for biofuels implementation are shown in Table G-6.
- The Governor and the Legislature would have the authority to change these targets (up or down) based on technical and/or economic feasibility.
- The Governor and Legislature could also set intermediate targets.

Table G-6. Goal levels and timing for biofuels implementation

Phase	Year	Percentage of Gasoline to be Replaced by Biofuels	Percentage of Diesel to be Replaced by Biofuels
1	2010	10% (E10 equivalent)	5% (B5 equivalent)
2	2015	15% (E15 equivalent)	10% (B10 equivalent)
3	2020	20% (E20 equivalent)	15% (B15 equivalent)
4	2025	25% (E25 equivalent)	20% (B20 equivalent)

Parties Involved: State of North Carolina, fuel retailers, fuel wholesalers, business owners, car dealers, biofuels producers, alternative-vehicle advocates, private vehicle owners.

Implementation Mechanisms

Information and education

Use information and education outreach to focus on voluntary methods of biofuels expansion. Provide the public with information on the use and effects of running their existing vehicles on ethanol. Target information and outreach about biodiesel use and effects to trucking and shipping companies, as well as smaller owner/operators in the State. Information should also be provided on where such vehicles can be purchased and on their environmental and fuel-saving benefits.

Technical assistance

Provide technical assistance through vehicle dealers, consumer technical support groups and public demonstrations.

Funding mechanisms, market-based mechanisms, and incentives

Pursue DOE and state funding for more alternative fuel pumps throughout the state and for introducing appropriate infrastructure throughout the state. Some federal tax incentives currently exist for the purchase of alternative-fuel vehicles. When the federal incentives expire, examine the feasibility/need to continue such incentives for alternative-fuel vehicles.

- Reduce or eliminate the motor fuels tax on biodiesel and ethanol (E85). Develop a system to provide for monthly credit for biodiesel and E85 blended fuel that would be equivalent to the state motor fuels tax owed on the biofuels portion of the fuel blend. (This could follow in the wake of elimination of tax on "home brew" biodiesel by the 2007 legislature.)

  Monthly tax credits would be claimed on the same form (Biodiesel and Fuel Alcohol Providers Form) marketers currently file with the North Carolina Department of Revenue (DOR) Motor Fuel Tax Division to pay fuel tax. This would reduce the pump price of biofuels because marketers would pass most of the credit on to consumers to be competitive. Credits could be paid out of General State Revenues, NCDOT highway funds. Credit would be revenue neutral because it would be equal to the tax that would have been paid by marketers for biofuel portion of blend.

- Develop a $0.25/gallon credit for biodiesel and ethanol use in North Carolina vehicles.

  As above, the tax credit would be claimed on the DOR Biodiesel and Fuel Alcohol Providers Form. Similarly, this would reduce price of biofuels because marketers pass the credit on to consumers in order to be competitive. General state revenues, or NCDOT highway funds could pay for the credit. Unlike above, this credit would not be revenue neutral because the state would be providing incentives for fuel sold to non-taxable entities (local and state government) as well as sales to taxable entities. However, only the biofuel portion of blended fuel would be eligible for a 25-cent credit. For example, a blend of 20% biodiesel with 80% petroleum diesel (B20 blend) would get a 5-cent credit.

- Create a tax credit for biodiesel producers

Codes and standards

This measure should include a mandated Renewable Fuel Standard (RFS), corresponding to the penetration rates listed above. The RFS should include a cost trigger, so that if the cost of

alternative fuels exceeds that of conventional fuels by more than a specified amount, the RFS would be temporarily removed. The cost trigger should be based on costs over a period of time, and not on spot prices. Additionally, production issues should be included in the trigger, such as water used in growing corn (or other crops) for the biofuels, such that the production of the biofuels does not increase GHG emissions or cause other resource problems.

Voluntary and or negotiated agreements

- Provide financial incentives for alternative fuels distributors.
- Provide state funds and/or loan guarantees for construction of alternative fuels distribution facilities.
- Provide grow receipt tax exemptions, production tax credits, and reduction in excise taxes on alt fuel sales.

Pilots and demos

Show examples of existing multi-fuel pumps in North Carolina that would provide a model for dispensing three alternative fuels: B20 biodiesel, E85 ethanol (85% ethanol/15% gasoline) and E10 (10% ethanol/90% gasoline). The State's experience with these vehicles should be publicized.

Research and development

- Pursue in-state biofuels production from a variety of sources.
- The State should push for significant federal funds for research and development needed to commercialize cellulosic ethanol technology and processes because this will be required to meet the ethanol targets for 2020 and beyond.
- Analyze and quantify the range of cost benefits that accrue to alternative-fuel vehicle owners.
- Research on the production of renewable electricity and hydrogen will be required in order to implement a cost-effective process.

Related Policies/Programs in Place

The Energy Policy Act of 2005 requires an increasing volume of renewable fuel to be included in the gasoline sold in the United States starting in 2006 with 4 billion gallons, increasing to 7.5 billion gallons by 2012. In this Act, renewable fuel includes motor vehicle fuel produced from grain, starch, vegetable, animal, or other biomass material, cellulosic biomass ethanol, waste derived ethanol, and biodiesel.

Type(s) of GHG Reductions

CO_2 emissions are reduced by offsetting the use of petroleum-derived gasoline and diesel. In order to assess the CO_2 benefit of using ethanol, the energy requirements of producing ethanol from starch need to be compared to the energy requirements of producing gasoline. Current research indicates that starch-based ethanol production provides up to 18%–29% reduction in CO_2 compared with gasoline production. To assess the benefits of using biodiesel, the overall energy required to produce biodiesel (e.g., life cycle costs and benefits) must be compared with the energy requirements of producing fossil fuel diesel. Hill et al. (2006) report that the energy available from biodiesel produced from soybeans is 93% greater than the fossil energy consumed

in producing it.[28] Thus, biodiesel reduces life cycle GHG emissions by as much as 41% compared with petroleum diesel.

Estimated GHG Savings and Costs per tCO_2e

Emissions reductions

The goals above would produce the following emissions reductions:

Note that some of these reductions would be attributable to the use of biofuels as a result of the national RFS in the Energy Policy Act of 2005.

Option No.	Mitigation Option	GHG Reductions ($MMtCO_2e$)			Net Present Value 2008–2020 (Million $)	Cost-Effective-ness ($/$tCO_2e$)	Level of Support
		2010	2020	Total 2008–2020			
TLU-6	Biofuels bundle	1.9	4.5	35.4	*Not quantified*		UC

Costs/cost-effectiveness

Two factors prevent us from making a defensible estimate of the costs associated with this option:

First, and most important, technology in alternative fuels production continues to be uncertain enough that a given cost estimate for any distance in the future is likely to be unreliable. For example, the cellulosic ethanol technologies that form the basis of many projections are just now being tested to determine if they can be successfully commercialized.

Second, the rulemaking for the national RFS is not yet complete, and that will necessarily shape the economics of alternative fuels consumed in North Carolina.

Data Sources:

- *Environmental, Economic, and Energetic Costs and Benefits of Biodiesel and Ethanol Biofuels*, Jason Hill, et al., University of Minnesota, published in Proceedings of the National Academy of Sciences of the United States of America, 103(30), July 25, 2006.
- *Well-to-Wheels Analysis of Advanced Fuel/Vehicle Systems—A North American Study of Energy Use, Greenhouse Gas Emissions, and Criteria Pollutant Emissions*, General Motors, Argonne National Laboratory and Air Improvement Resource, Inc., May 2005.
- "Documentation of Inputs to Macroeconomic Assessment of the Climate Action Team Report to the Governor and Legislature," California Climate Action Team, January 2006.
- "State and Federal Standards for Mobile-Source Emissions," National Research Council of the National Academies, Washington, DC, 2006.

Quantification Methods: Well-to-wheels CO_2 equivalent emission factors take into account the energy required to produce, process, and transport each fuel type (i.e., starting with the oil well

[28] See Data Sources below.

for gasoline and the crop for starch-based ethanol). Such factors from a recent Argonne National Laboratory Study were used to estimate the benefits of offsetting conventional gasoline with starch-based ethanol in the amounts specified by the ethanol goals. Based on this source, the use of starch-based ethanol to replace gasoline is assumed to reduce CO_2e by 18.3%. The quantity of diesel fuel projected to be replaced in North Carolina with biodiesel was estimated based on the penetration rates of the above goals. A reduction in CO_2 emissions of 41% was applied to the quantity of diesel fuel replaced by biodiesel (Hill et al., July 2006).

Key Assumptions: This policy option assumes that the ethanol and biodiesel demand will be met with fuels available from a national market. Therefore, it is expected that the ethanol production would be starch-based, and the emission factors used here reflect that.

Key Uncertainties

Some uncertainty remains regarding the ethanol production life cycle emission factors as well as the availability of ethanol and biodiesel at the levels needed by this policy.

Contributing Issues

EPA has reported that the use of B20 biodiesel can lead to a 21% reduction in hydrocarbons (HCs), 11% reduction in carbon monoxide (CO), and a 10% reduction in particulate matter (PM). Toxic emission reductions can also be significant. However, some forms/brands of biodiesel can lead to increased exhaust emissions of nitrogen oxides (NO_x) and some air toxics, depending on feedstock and blend level. EPA reports a 2% increase in NO_x emissions for B20 blends. In contrast, according to a recent analysis performed by the National Renewable Energy Laboratory, certain brands of biodiesel, such as Blue Sun Biodiesel B20, can reduce NO_x emissions by 4% to 5%. Effects on newer diesel vehicles are likely to be different. An increased penetration of biofuels reduces our dependency on foreign fossil fuel.

Feasibility Issues

Members of the CAPAG have expressed concern over the land and water resources needed to produce the amount of biofuels required by this policy option.

Status of Group Approval

Approved.

Level of Group Support

Unanimous consent.

Barriers to Consensus

None.

TLU-7. Procure Efficient Fleets

Mitigation Option Description

Reduce GHGs by increasing the efficiency of vehicle fleets generally, beginning with government lead by example. Also increase fleet use of alternative fuels.

Mitigation Option Design

Goals: Increase government fleet use of low-GHG fuels and more efficient vehicles to reduce GHG emissions from fleets. In addition to CO_2 reductions, reduce emissions affecting ozone, sulfur, and carbon monoxide loadings.

Timing: Statewide GHG reduction targets for fleets phased in over a period of probably 8–10 years to allow fleet turnover to absorb most of the costs of replacing existing fleets. Other measures regarding more frequent maintenance and part specifications could be phased in much faster.

Parties Involved: All government fleet vehicle operators, possibly private fleet operators, on-road passenger cars owners, light-duty trucks owners, bus fleet owners/operators, heavy-duty truck owners/operators.

Other: Some places in North Carolina are already implementing green vehicle fleets in whole or in part.

Implementation Mechanisms

Statewide policy specifying target adoption rates can come with an incentive or enforcement package.

Although hybrid cars and higher-fuel efficiency cars comprise the biggest part of the potential market for creating greener state vehicle fleets, better purchasing decisions on tires and maintenance schedules can also contribute significantly to higher fuel efficiencies and lower emissions.

Alternative fuel use credits can be implemented to ensure the use of cleaner compressed natural gas fuels and more efficient vehicles.

Credit can be accrued by the use of biodiesel, ethanol, compressed natural gas (CNG), propane, hydrogen, electricity and by the purchase of advanced technology vehicles such as hybrid electric vehicles. Such legislation was introduced but not passed during the 2005 session (SB1148). Text from the bill is offered here as an example:

> The State fleet shall accrue a total of 2,000,000 alternative fuel use credits during each calendar year 2006 and 2007. The State fleet shall accrue a total of 5,000,000 alternative fuel use credits during each calendar year 2008 and 2009. The State fleet shall accrue a total of 10,000,000 alternative fuel use credits during the calendar year 2010 and each calendar year thereafter.
>
> (e) Formulas for Calculating Credits.—Alternative fuel use credits are calculated as follows:

> (1) Subject to subdivision (2) of this subsection, one alternative fuel credit accrues for each one gallon of one hundred percent (100%) alternative fuel utilized by a State fleet vehicle. When alternative fuel is blended with petroleum-based fuel, the alternative fuel credit accrues for each one gallon of alternative fuel utilized by a State vehicle at a rate that is based on the percentage of alternative fuel that is utilized by a State fleet vehicle. (For example, one alternative fuel use credit accrues for every five gallons of B20 that is utilized by a State fleet vehicle.)

Thus, in 2012, the goal of that language is to move 10,000,000 gallons of fuel from fossil to bio.

Related Policies/Programs in Place

Many cities, including Raleigh, Durham, Greensboro, Hickory, Conover, Charlotte, and others have converted part or all of their fleets to cleaner-burning fuels such as B20, CNG, ethanol, and electric hybrids. North Carolina has vigorously acquired flexible-fuel vehicles (FFVs) and uses E85, E10, and biodiesel on more than 3,000 vehicles.[29]

Budget provision 19.5 of the 2005 North Carolina budget required the displacement of 20% petroleum from state fleet vehicles by 2010. These mandated goals (affecting state fleets greater than 10 vehicles) have expanded use of biodiesel (B20) and ethanol (E85). For example NCDOT has already announced expansion of B20 refueling to more than 100 state refueling facilities in North Carolina.

Type(s) of GHG Reductions

Mainly CO_2.

Estimated GHG Reductions and Costs (or Cost Savings)

Because most of the GHG reductions and costs for this option come from alternative fuel use, they are incorporated into costs and benefits reported under TLU-6, Biofuels Bundle.

Data Sources: See TLU-6.

Quantification Methods: See TLU-6.

Key Assumptions: See TLU-6.

State procurement of efficient fleets will continue to help the state lead by example and spur the alternative fuels market (both provision and infrastructure). CCS analysis suggests that this option will not add meaningful additional CO_2 emissions reductions to the reductions that would be gained through TLU-6 and through existing actions. Nonetheless, a public relations effort would beneficially publicize the achievements thus far, and how other fleets could benefit as well.

Key Uncertainties

None cited.

[29] See http://www.eere.energy.gov/afdc/pdfs/37133.pdf#search=%22green%20vehicle%20fleet%2C%20NC%22

Additional Benefits and Costs

None cited.

Feasibility Issues

None cited.

Status of Group Approval

Approved.

Level of Group Support

Unanimous consent.

Barriers to Consensus

None.

TLU-8. Idle Reduction / Elimination Policies

Mitigation Option Description

Implement state and local policies to reduce hours of operation and thus emissions from idling trucks and buses (principally), perhaps off-road engines as well.

Mitigation Option Design

Goals:

- To reduce GHG emissions from heavy vehicles.
- Reinforce TSE support.

Timing: Phased in; at full strength within 5 years of initiation.

Parties Involved: All heavy truck owners/operators, public bus fleet owners/operators, private bus fleet owners/operators.

Other: Exemptions for emergency vehicles, maintenance tasks, and similar cases. Note that "idling" here does not cover idling while stopped in traffic.

Implementation Mechanisms

This would require working with trucking groups, truck stops, and places where trucks stop, as well as with government to formulate an agreeable policy approach, phasing schedule, and legislative content.

Related Policies/Programs in Place

About 15 states and a number of local governments have adopted anti-idling legislation.[30] More are sure to follow or are already in discussion at some level. Toronto has had a law in place since 1996. Many North Carolina counties and the State Board of Education (Policy No. EEO-M-003) have already adopted school bus idling policies.[31] The Clean School Bus USA program (EPA) should also be consulted.[32]

Type(s) of GHG Reductions

Mainly CO_2, some black carbon.

Estimated GHG Reductions and Costs (or Cost Savings)

Anti-Idling GHG Reduction Potential in 2010, 2020 ($MMtCO_2e$): 0.1, 0.2.

Anti-Idling Cost-Effectiveness: –$4/ton (cost saving).

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[30] See http://atri-online.org/research/idling/Cab%20Card%20July%202006.pdf

[31] See http://www.ncbussafety.org/idling.html

[32] See http://www.epa.gov/cleanschoolbus/

Data Sources:

Reductions

Idle reduction technologies and policies could reduce per-vehicle fuel use by 3% to 9% annually:

J. Ang-Olson and W. Schroeer, "Energy Efficiency Strategies for Freight Trucking: Potential Impact on Fuel Use and Greenhouse Gas Emissions," *Transportation Research Record*.

Reductions and costs

American Transportation Research Institute, "Idle Reduction Technology: Fleet Preferences Survey," February 2006, for technology costs.

EPA SmartWay Transportation Partnership (www.epa.gov/otaq/smartway/idlingtechnologies.htm#truck-mobile) for technology costs.

"Analysis of Technology Options to Reduce the Fuel Consumption of Idling Trucks," ANL/ESD-43, Argonne National Laboratory, Transportation Technology R&D Center, June 2000, for information on technology impacts.

Quantification Methods/Key Assumptions:

Impacts

Impacts assume the penetration rates shown in Table G-7.

Table G-7. Assumed penetration rates and resulting impacts

10%	Percent of heavy-duty travel (by VMT) by public sector.
50%	Percent of public sector heavy-duty VMT observing anti-idling through 2012.
40%	Percent of private sector heavy-duty VMT observing anti-idling through 2012.
80%	Percent of public sector heavy-duty VMT observing anti-idling through 2020.
70%	Percent of private sector heavy-duty VMT observing anti-idling through 2020.
95%	VMT-equivalency conversion factor of idling to non-idling vehicles in 2012.
95%	VMT-equivalency conversion factor of idling to non-idling vehicles in 2020.
2.05%	Calculate expected percent reduction in VMT-equivalency of conventional vehicles for 2010.
3.55%	Calculate expected percent reduction in VMT-equivalency of conventional vehicles for 2040.

Costs

The cost analysis assumes a 5-year lifetime for idling technology equipment, applied to 80% of Class 8 vehicles starting in 2008 and 100% of Class 8 vehicles starting in 2015, at a cost of $6,000 per vehicle and a $2.40 per gallon diesel cost savings.

Program administration costs, enforcement costs, fines, and reduced vehicle maintenance costs have not been factored into the cost analysis.

Key Uncertainties

The use of truck stop electrification would increase emissions from electricity generation. Equipment cost and lifetime will vary by technology employed. The cost value selected was

based on cost data summarized by American Transportation Research Institute, representing the capital costs of a variety of idle reduction technologies. The cost of $6,000 per vehicle represents a mix of higher and lower technology costs. The cost analysis does not take into account the number of vehicles that have already installed idle reduction technologies. The fuel cost assumed here is based on long-term projected fuel costs. Increases in this assumed fuel cost will lead to greater cost savings for this measure.

Additional Benefits and Costs

None cited.

Feasibility Issues

None cited.

Status of Group Approval

Approved.

Level of Group Support

Unanimous consent.

Barriers to Consensus

None.

TLU-9. Diesel Retrofits

Mitigation Option Description

Reduce diesel emissions from older diesel engines and emission systems through retrofit and/or retirement. Create incentives and encourage retrofits through a combination of funding, education, and promotion.

Mitigation Option Design

Goals:

- Reduce children's exposure to diesel emissions by retrofitting school buses in North Carolina with diesel oxidation catalyst (DOC) control devices, and/or diesel particulate filters, which have the auxiliary benefit of reducing some GHGs and carbon black.
- Speed retirement and/or retrofit of all older diesels through information and incentives.

Parties Involved: North Carolina school bus owners/operators, all North Carolina diesel truck owners/operators.

Other: None cited.

Implementation Mechanisms

- Utilize various funding mechanisms to purchase DOC pollution control devices and/or particulate traps for school buses that are not equipped with pollution control devices.
- Information and education: An information and education component is needed to provide truck and bus owners, school districts, and municipal organizations with information regarding the significant emission reductions that could be achieved by retrofitting or retiring certain truck or bus engines with high annual emissions and replacing them with vehicles meeting the new emission standards. Provide information on potential funding partners, grants, or loans available from a number of organizations for this purpose.
- Funding mechanisms or incentives: Develop a loan or grant program that allows truck owners to accelerate new vehicle purchases or to apply retrofit technologies to their fleets.

Related Policies/Programs in Place

Currently in North Carolina, there is an ongoing effort to retrofit school buses across the state with diesel pollution control devices. An estimated 15% of the school buses in the state are already equipped with some type of pollution control device. Sources of funding include federal and state grants, local funding, and gifts from private industry. The primary purpose of these diesel pollution control devices is to reduce particulate matter.

Legislation currently under consideration (HB 1912: School Bus Retrofits in Non-attainment Areas) addresses school bus retrofits.

The legislation establishes a pilot program to be administered by North Carolina DENR to provide grants to retrofit school buses in the non-attainment and maintenance areas across North Carolina. The bill does not specify the use of any particular control technology.

Type(s) of GHG Reductions

DOCs and particulate filters remove varying amounts of pollutants depending on design and manufacturer. EPA has verified a range of substantial (20% to 90%) reductions in PM, CO, NO_x, HC;[33] PM contains black carbon.

Estimated GHG Reductions and Costs (or Cost Savings)

Emissions impacts

Multiple fuel economy studies have reported that either DOCs have no impact on fuel economy or have a slight decrease that is not statistically significant.

This mitigation option sets no adoption or penetration goals, and GHG reductions are secondary. Further, given the variability in NO_x reductions, it is impossible to estimate GHG reductions without knowing the types of DOCs likely to be used. As a result, GHG reductions are not quantified.

Costs

In 2000, the CARB estimated the expected cost of DOC technology by horsepower rating as shown in Table G-8.

Table G-8. CARB-estimated costs of DOC technology

Engine Horsepower	Hardware Cost
40	$400–$600
100	$680–$1,356
275	$2,100–$3,700
400	$2,800–$3,700
1,400	$10,000–$20,000

Recent estimates suggest the costs for DOCs in retrofit applications are decreasing slightly and range from under $500 to $1,250 for engines in the 100–200 horsepower category and from less than $1,000 to $1,750 for engines in the 200–500 horsepower category. DOC installation typically takes 1–2 hours. If installation service is provided by the technology suppliers or agents, the cost ranges from less than $100 to about $200. Since DOC installation is relatively straightforward, fleet mechanics will sometimes install the DOCs themselves after receiving training from the DOC supplier, which cuts installation costs. Since DOCs are virtually maintenance free—requiring only periodic checks of the catalyst and exhaust system for mechanical integrity—no additional maintenance costs are incurred.[34]

[33] http://www.epa.gov/otaq/retrofit/retroverifiedlist.htm

[34] Western Regional Air Partnership, Offroad Diesel Retrofit Guidance Document, Volume 2, Section II.

Because this option leaves open the choice of technology—and within technologies, there is a wide range of costs and effectiveness—it is not possible to provide a cost-effectiveness estimate for this option. However, as a way to suggest potential cost-effectiveness values, we provide excerpts from two recent studies of policy options to reduce diesel emissions, one from North Carolina, and one national.

1. Southern Alliance for Clean Energy and Carolinas Clean Air Coalition, "A Case for the Healthy School Bus: Lessons From the Field. Results of a Cabin Air Quality Demonstration Project on Diesel School Buses in Charlotte, North Carolina," December 2006.[35]

   This report is quite thorough, and though it does not give cost-effectiveness figures, it provides in-depth, North Carolina testing-based discussion of the merits of different school bus retrofit technologies.

   > "Advanced pollution control technologies, cleaner fuels and model management practices are currently being implemented throughout the state considerably reducing diesel soot, but more is needed. Only 15 cities or counties in North Carolina have taken action to reduce emissions from their local school bus fleets. Of the approximately 13,600 yellow school buses in the state, only 1,159 (12%) school buses are retrofitted or will be retrofitted soon with pollution control devices."
   >
   > "The retrofit combination of a diesel particulate filter and a closed crankcase ventilation system demonstrate virtual elimination of all diesel soot inside the school bus cabin."
   >
   > "Concentrations of black carbon were elevated on all buses except the bus retrofit with a DPF [diesel particulate filter] and CCV [closed crankcase ventilation]. Black carbon is a significant contributor to global warming and is the main component of diesel soot, making up 94% of a diesel soot particle.
   >
   > "Diesel soot gathers on snowy surfaces, attracting more sunlight, which in turn melts more snow and ice. According to NASA [National Aeronautics and Space Administration] studies, this soot is twice as potent as carbon dioxide in changing global surface temperature in the Northern Hemisphere and the Arctic."
   >
   > "The retrofit combination of a diesel particulate filter with the closed crankcase ventilation system (Spiracle used in this test) demonstrated elimination of all diesel soot particles (PM2.5, ultrafine particles and black carbon) [*CCS note: inside the school bus cabin*] in the Charlotte demonstration and in all other cities where tests were conducted. The consistent evidence and effectiveness of these technologies in all cities confirms results found in the Charlotte demonstration. We recommend this retrofit combination, a DPF and a closed crankcase ventilation system, as the best solution for reducing diesel soot inside school buses. These devices should be installed on all applicable school buses in North Carolina."

2. Environmental Defense, "Cleaner Air for America: The Case for a National Program to Cut Pollution from Today's Diesel Engines," 2005.[36]

   This report estimates that public investment in a technology-focused diesel control program could pay substantial health and health cost dividends. The report evaluates a broader proposed program than the one proposed in this option, but the figures may help give a sense of what at least one group believes the returns may be

[35] http://www.cleanenergy.org/resources/reports/NC%20Diesel%20Report%20final.pdf

[36] http://www.environmentaldefense.org/documents/4488_cleanerairamerica.pdf

> "Investments in a national diesel control program yield healthy returns. An investment in diesel engine retrofits ranging from $600 million to $1.6 billion yields a multi-year stream of health benefits with a net present value ranging from $10.6 to $19.2 billion."
>
> "Using EPA's valuation methodologies, we found that investment in a national diesel pollution control program will yield healthy returns. Figure 1 shows the lump sum costs of applying the two technology scenarios to school buses, transit buses and construction equipment in the 50 most populated cities ranged from $600 million to $1.6 billion. The net present value of the resulting health benefits far exceeded these costs, and ranged from $10.6 billion to $19.2 billion."
>
> "Our two scenarios assumed installation of DPFs and DOCs within the studied counties. Because these two technologies vary significantly in applicability and pollutant removal efficiencies, these two scenarios illustrate the range of costs to achieve steep reductions from a limited set of engines and more modest reductions over many more engines. The scenarios are illustrative. The appropriate mix of pollution reduction strategies will vary widely across communities."

Quantification Methods: Not applicable.

Key Assumptions: None cited.

Key Uncertainties

None cited.

Additional Benefits and Costs

The primary benefits produced would be in health, especially children's health.

Feasibility Issues

None cited.

Status of Group Approval

Approved.

Level of Group Support

Unanimous consent.

Barriers to Consensus

None.

TLU-11. Pay-As-You-Drive Insurance

Mitigation Option Description

Pay-As-You-Drive (PAYD) pricing converts a portion of insurance to a variable cost with respect to vehicle travel, so premiums are directly related to mileage. PAYD makes insurance more actuarially accurate and allows motorists to save money when they reduce their mileage. The less you drive, the more you save.

Mitigation Option Design

Goals: To reduce GHG emissions from automobiles by influencing individual drivers to reduce their annual VMT.

Timing: Proposal would require insurance companies to offer PAYD as part of their menu of insurance choices in North Carolina. A pilot project could be implemented first on a small scale as soon as possible. Option design is to have full North Carolina light-duty fleet PAYD coverage by 2020.

Parties Involved: Insurance companies, all motorists insured in North Carolina.

Implementation Mechanisms

Require insurance companies to offer PAYD as part of their menu of insurance choices in North Carolina.

Implementation technologies to be determined through rulemaking, taking into account available and other required technology.

- Insurance companies could bill motorists based on their monthly vehicle mileage similar to other utilities or annually.
- Variations in the policy design can address geographic and/or equity concerns.

Related Policies/Programs in Place

General Motors Acceptance Corporation (GMAC) and OnStar offer low-mileage discount rates.[37]

Since mid-2004, the GMAC Insurance has offered mileage-based discounts to OnStar subscribers located in certain states. The system automatically reports vehicle odometer reading at the beginning and end of the policy term to verify vehicle mileage. Motorists who drive less than specified annual mileage receive insurance premium discounts of up to 40%, as indicated in Table G-9.

[37] See http://www.onstar.com/us_english/jsp/low_mileage_discount.jsp

Table G-9. Discounts for motorists who drive less than specified annual mileage

Miles	Discount
1–2,500	40%
2,501–5,000	33%
5,001–7,500	28%
7,501–10,000	20%
10,001–12,500	11%
12,501–15,000	5%
15,001–99,999	0%

Value Pricing Pilot Program PAYD projects[38]

This Federal Highway Administration's Value Pricing Pilot Program is now providing funding for PAYD insurance simulation projects in Georgia and Massachusetts.

Distance-Based Program

Progressive Insurance[39] offers distance-based insurance in Oregon, Michigan, and Minnesota. The program uses GPS to track vehicle location and use.

TripSense℠

Progressive Insurance also offers a distance and safety-based program: "Safer drivers and people who drive less than average should pay less for auto insurance. That's why we created the revolutionary TripSense discount program, which measures your actual driving habits and allows you to earn discounts on your insurance by showing us how much, how fast, and what times of day you drive. TripSense gives you more control over what you pay for insurance, as your driving habits determine your discount."[40]

Type(s) of GHG Reductions

CO_2

Estimated GHG Reductions and Costs (or Cost Savings)

GHG Reduction Potential in 2010, 2020 ($MMtCO_2e$): 2.3, 5.3.

Cost-Effectiveness: Expected net savings.

Data Sources: See below.

Quantification Methods:

- VMT impacts: literature. Pilot studies and empirical experience with other marginal costs of use find that PAYD can reduce VMT by between 8% and 20%. If phase-in/ramp-up, then:

[38] See http://www.fhwa.dot.gov/policy/13-hmpg.htm

[39] See http://www.progressive.com

[40] See http://tripsense.progressive.com/about.aspx

- Apply reductions to LDV VMT only:

  2012 reduction = statewide LDV × 4% reduction = 3.6% of total statewide HDV + LDV

  2020 reduction = statewide LDV × 8% reduction = 7.2% of total statewide HDV + LDV
- Convert to CO_2
- PAYD: The Arizona PIRG Education Fund analyzed the potential GHG savings from a PAYD automobile insurance policy. The strategy for a PAYD policy analyzed assumes that insurers are required to offer mileage-based insurance for certain elements of vehicle insurance, including collision and liability. The PIRG Education Fund assumes the PAYD policy is required, phased in over time, and that all drivers in Arizona are eventually covered.

  To calculate GHG savings, the Arizona PIRG Education Fund converted Arizona state automobile collision and liability insurance expenditures to an insurance cost per mile (6.4 cents per mile). If insurance consumers pay 80% of their collision and liability insurance on a per-mile basis, then drivers would be assessed a charge of about 5.1 cents/mile. This per-mile insurance charge would reduce VMT by about 8 %.[41] (To put this charge in context, at 20 mpg, 5.1 cents/mile = ~$1/gallon of gasoline.)

  CCS compared the PIRG Education Fund results for estimated reductions in VMT with other studies of PAYD policies, including those produced by the Economic Policy Institute and Resources for the Future (RFF). CCS found that the Arizona PIRG estimates were comparable to other estimates, which ranged from 8% to 20%. The 8% reductions estimates CCS used for estimated reductions in VMT and GHG emissions reductions fell within the lower range of the comparable estimates.

- Net present value/cost-effectiveness: The success of the Progressive Insurance pilot in Texas suggests that there is an unmet demand for more choice in auto insurance.

Key Assumptions:

- State regulation of the North Carolina automobile insurance industry requires insurance companies to offer PAYD insurance.
- Eventual application of PAYD insurance to the entire fleet of North Carolina light-duty motor vehicles.

Key Uncertainties

The specifics of the PAYD insurance programs are to be determined, and the actual effects of PAYD insurance on driver behavior are subject to some significant uncertainty.

Additional Benefits and Costs

Equity Impacts

"Current vehicle insurance pricing significantly overcharges motorists who drive their vehicles less than average each year and undercharges those who drive more than average within each

[41] Elizabeth Ridlington and Diane E. Brown, *A Blueprint for Action: Policy Options to Reduce Arizona's Contribution to Global Warming*, Arizona Public Research Interest Group Education Fund, April 2006, pp. 25–26. http://www.arizonapirg.org/AZ.asp?id2=23683. See also: http://www.serconline.org/payd/links.html, which links to a wide variety of PAYD studies and materials.

price class" (Edlin, 1999; Litman, 2001). Since lower-income motorists drive their vehicles significantly less on average than higher-income motorists, this is regressive. Distance-based insurance is fairer than current pricing because prices more accurately reflect insurance costs.

"Distance-based pricing benefits lower-income drivers who otherwise might be unable to afford vehicle insurance and who place a high value on the opportunity to save money by reducing vehicle mileage. It benefits lower-income communities that currently have unaffordably high insurance rates…."[42]

Other equity issues may be addressed through policy design.

Feasibility Issues

None cited.

Status of Group Approval

Approved.

Level of Group Support

Supermajority.

Barriers to Consensus

Concern about impacts on high-mileage drivers.

[42] Todd Litman, "Pay-As-You-Drive Vehicle Insurance: Converting Vehicle Insurance Premiums Into Use-Based Charges," *TDM Encyclopedia*, Victoria Transport Policy Institute, December 2005. http://www.vtpi.org/tdm/tdm79.htm

TLU-12. Advanced Technology Incentives

Mitigation Option Description

Technology will play a vital role in dramatically reducing carbon emissions from the cars of the future. Fuel cells, plug-in hybrid, low-weight carbon-fiber bodies, and other technologies will require research, development, and commercialization. Because of its strong research university and its high-tech and auto parts manufacturing, there may be an opportunity for North Carolina (especially through the Department of Commerce) to encourage advanced automobile technology research and recruit a new generation of manufacturers.

Studies can evaluate whether there is an economic opportunity around the development and commercialization of advanced technology vehicles and suggest possible models for the Department of Commerce to take advantage of such opportunities.

Mitigation Option Design

Goals:

- To enable North Carolina's economy to establish itself in the research, development, and commercialization of advanced automotive technologies.
- To grow North Carolina's capacity to recruit sustainable industry.

Timing: Long-range (e.g., 10-year) investment plan.

Parties Involved: North Carolina Department of Commerce, North Carolina Economic Development Board, university research programs, manufacturers.

Other: None cited.

Implementation Mechanisms

- Tax incentives.
- Education of industrial recruiters.
- Possible formation of a North Carolina Advanced Technology Institute.

Related Policies/Programs in Place

There are existing sustainable business recruiting efforts by the Department of Commerce.

Type(s) of GHG Reductions

CO_2.

Estimated GHG Reductions and Costs (or Cost Savings)

By their nature, R&D initiatives cannot be predicted to produce certain kinds of technologies and, hence, cannot be predicted to produce certain amounts of emissions reductions. This policy

option potentially has substantial upside emissions benefits, but CCS is unable to estimate impacts for this level of policy intent.

Data Sources: Not applicable.

Quantification Methods: Not applicable.

Key Assumptions: Not applicable.

Key Uncertainties

None cited.

Additional Benefits and Costs

None cited.

Feasibility Issues

None cited.

Status of Group Approval

Approved.

Level of Group Support

Unanimous consent.

Barriers to Consensus

None.

TLU-13. Buses – Clean Fuels

Mitigation Option Description

Expand TLU-7 to include transit bus fleets.

Mitigation Option Design

Goals: Included with TLU-6.

Timing: Same.

Parties Involved: Transit bus fleet owners and operators.

Other: None cited.

Implementation Mechanisms

None cited.

Related Policies/Programs in Place

None cited.

Type(s) of GHG Reductions

CO_2.

Estimated GHG Reductions and Costs (or Cost Savings)

Included in TLU-6.

Data Sources: Same.

Quantification Methods: Same.

Key Assumptions: None cited.

Key Uncertainties

None cited.

Additional Benefits and Costs

None cited.

Feasibility Issues

None cited.

Status of Group Approval

Approved.

Level of Group Support

Unanimous consent.

Barriers to Consensus

None.

Appendix H
Agriculture, Forestry, and Waste Management Mitigation Option Recommendations

Summary List of Mitigation Option Recommendations

Option No.	Mitigation Option Name	GHG Reductions ($MMtCO_2e$)			Net Present Value 2007–2020 (Million $)	Cost-Effective-ness ($/$tCO_2e$)	Level of Support*
		2010	2020	Total 2007–2020			
AFW-1	Manure Digesters & Energy Utilization	0.2	0.9	6.4	199	31	UC
AFW-2	Biodiesel Production (Incentives for Feedstocks and Production Plants)	0.2	0.8	5.1	286	56	UC
AFW-3	Soil Carbon Management (Including Organic Production Methods Incentives)	0.2	0.2	3.0	–16	–5	UC
AFW-4a	Preservation of Working Land—Agricultural Land	0.2	0.3	2.6	290	114	UC
AFW-4b	Preservation of Working Land—Forest Land (formerly AFW-7)	1.7	4.3	36	112	3	UC
AFW-5	Agricultural Biomass Feedstocks for Electricity or Steam Production	0.009	0.02	0.2	10	54	UC
AFW-6	Policies to Promote Ethanol Production	0.9	6.9	38	200	5	UC
AFW-7	*Moved to AFW 4a*						
AFW-8	Afforestation and/or Restoration of Non-forested Lands	0.2	2.4	15	128	9	UC
AFW-9&10	Expanded Use of Forest Biomass and Better Forest Management	1.5	5.9	48	–639	–13	UC
AFW-11	Landfill Methane and Biogas Energy Programs	1.1	2.9	20	23	1	UC
AFW-12	Increased Recycling Infrastructure and Collection	0.2	0.5	4.1	52	13	UC
AFW-13	Urban Forestry Measures	1.4	4.3	34	–376	–11	UC
	SECTOR TOTAL AFTER ADJUSTING FOR OVERLAPS	7.8	29	212	270	1	
	REDUCTIONS FROM RECENT ACTIONS (none)	0	0	0	0	0	
	SECTOR TOTAL PLUS RECENT ACTIONS	7.8	29	212	270	1	

* UC = unanimous consent (all agree).

AFW-1. Manure Digesters & Energy Utilization

The methane emissions inherent from the anaerobic decomposition process of manure and other wastes may be captured and used as an energy source. In so doing, it is possible to both reduce methane emissions and to offset fossil-based energy. However, the cost of emission capture and energy production can be higher than the value of the energy collected, making this option cost prohibitive for producers operating in a tight margin business. This option covers programs to increase the number of methane capture and energy recovery projects using manure or other waste (including food processor waste).

Mitigation Option Design

Provide economic incentives/cost offsets for producers interested in manure to energy projects.

Goals: Capture 20% of available methane from confined animal operations by 2020 for use in energy projects. The policy is designed to apply to hog farms and dairies in the state.

Timing: By 2010, implement projects to capture 5% of available methane energy at hog farms and dairies. By 2020, implement projects to capture 20% of methane energy.

Parties Involved: NC Farm Bureau, Department of Environment and Natural Resources. (DENR), NC Department of Agriculture and Consumer Services (NCDA&CS), livestock producers

Other: Due to the levels of emissions and the cost-effectiveness estimated for applying this option to livestock operations in North Carolina, this policy is designed to address hog farms primarily and could also cover dairy producers.

Implementation Mechanisms

- Increased education and outreach to farmers regarding the opportunities for manure digesters. Most farmers cannot implement these recommendations without technical assistance. Traditionally, many farmers rely on the United States Department of Agriculture's (USDA's) Natural Resource Conservation Service (NRCS) and North Carolina Cooperative Extension Service (NCCES) for this technical assistance. Additional training is needed for the technical assistance providers in order to better promote the technology.
- Incentives in the form of tax breaks (sales and/or income) for incurred capital costs. Current tax incentives are income tax credits up to 50% of tax burden. During the initial stages of this industry, income is likely to be low and therefore income tax credits will be drastically reduced from the maximum allowed. Restructuring the tax credit to allow for greater recovery of the capital costs will provided a greater incentive to install manure digesters. Exempt manure digester equipment from property and/or sales tax. Existing regulations exempt pollution abatement equipment from property tax, similar exemptions are needed for manure digesters.

- Increased funding for voluntary programs such as NC GreenPower (GreenPower) and NC Agriculture Cost Share (Ag Cost Share) to help offset costs of installing and maintaining manure digesters. These existing programs have a limited ability to fund manure digesters through higher electricity payments (GreenPower) and grants for installation costs (Ag Cost Share). Additional funding for these programs is another incremental step in reaching the recommended goal.
- Increased research to improve return on investment for digesters. Technological improvements have the potential to increase efficiency and lower costs thereby making the manure digesters more economically attractive.
- Allow utilities to pay above avoided cost rates for electricity purchased from manure digesters. Currently, utilities are required to pay small power producers the equivalent of what it would cost the utility to generate the electricity. Allowing the utilities to pay above avoided cost will increase the return on installing a manure digester.
- Education for farmers of power purchase agreements and interconnection with the grid. Farmers should be aware of the interconnection standards required by their local utility including the equipment that will be needed as well as any charges that may apply. Power purchase agreements are essentially the contract between the farmer and the utility that includes rates and length of contract. Making these items as simple as possible and educating the farmers about them will enhance the awareness of the procedures needed to provide electricity to the grid.

Related Policies/Programs in Place

- NRCS cost share program.
- NC Renewable Energy Property tax credit. State income tax credit for 35% of construction costs not to exceed $2.5 million or 50% of tax burden.[1]
- United States Environmental Protection Agency (US EPA) AgSTAR Program.
- Federal Renewable Electricity Production Tax Credit.
- USDA Farm Bill Renewable Energy and Energy Efficiency Loan and Grant Program—The Renewable Energy and Energy Efficiency loan and grant program was established under Section 9006 of the 2002 Farm Bill. It provides loan guarantees and grants to agricultural producers and rural small businesses for the purchase and installation of renewable energy systems or for energy efficiency improvements. Loan guarantees cover up to 50% of a project's cost, not to exceed $10 million. Grants are available for up to 25% of a project's cost, not to exceed $250,000 for energy efficiency improvements and $500,000 for renewable energy systems. These loans and grants are expected to reduce greenhouse gas emissions by 0.97 million metric tons, replace 821 million barrels of foreign oil and generate almost 2 million kilowatt hours of electricity annually. USDA has funded more than 800 loans and grants since the renewable energy program began in fiscal year (FY) 2003.

[1] North Carolina Incentives for Renewable Energy: http://www.dsireusa.org/library/includes/incentive2.cfm?Incentive_Code=NC19F&state=NC&CurrentPageID=1&RE=1&EE=0

Type(s) of Greenhouse Gas (GHG) Reductions

- **CH_4:** methane is captured and typically combusted in an energy recovery system or flared. Small amounts of nitrous oxide (N_2O) and CH_4 are emitted from the combustion process.
- **CO_2:** carbon dioxide is reduced when the methane is converted to energy and that energy is used to offset fossil-based energy (e.g., coal-fired electricity, natural gas). Small amounts of N_2O and CH_4 are also reduced from the fossil-based energy that is offset.

Estimated GHG Reductions and Costs (or Cost Savings)

GHG Reduction Potential in 2010, 2020 ($MMtCO_2e$): 0.2, 0.9.

Net Cost per $MtCO_2e$: $32.

The cost per ton is the weighted average for dairy ($185) and swine ($31). Since only a very small fraction of the emission reductions are achieved at dairies, the weighted cost-effectiveness is nearly identical to that estimated for swine operations. Most of the reductions come from the swine sector. For beef feedlots, the cost-effectiveness estimate is much higher ($1,641; due to much lower methane emissions/head), so the Technical Work Group (TWG) does not recommend adopting this policy to address feedlots. These cost estimates include the effects of grants for renewable energy projects from the Federal Farm Bill but do not include the effects of other existing federal and state tax incentives.

Data Sources: NC GHG Inventory & Forecast (I&F), North Carolina State University (NCSU) technology determinations for swine farms,[2] other technical reports and presentations on implementing digesters at confined animal operations.[3]

Quantification Methods:

GHG Benefit. Methane emissions data from the I&F was used as the starting point to estimate the GHG benefits of capturing and controlling the volumes of methane targeted by the policy and to add in the additional benefit of electricity generation using this captured methane (through offsetting fossil-based generation). For 2010 and 2020, the GHG benefit for capturing methane was estimated by multiplying the methane emissions from dairy, feedlot, and swine operations by the applicable goal (5% or 20%) and then by an assumed collection efficiency of 75%,[4] and converting to carbon dioxide equivalent (CO_2e).

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[2] NCSU Animal and Poultry Waste Management Center, Development of Environmentally Superior Technologies: Phase 3 Report Between the Attorney General of North Carolina and Smithfield Foods, Premium Standard Farms, and Frontline Farms, March 8, 2006, information from this study compiled for the Barham swine farm.

[3] Leonard Bull, Animal and Poultry Waste-to-Energy, PowerPoint presentation, North Carolina State University, See http://www.cals.ncsu.edu/waste_mgt/waste%20to%20energy.pdf, accessed June 2006. See also http://www.methanetomarkets.org/resources/ag/docs/animalwaste_prof_final.pdf, accessed March 2006. Williams, Douglas, Valley Air Solutions, presentation "Joseph Gallo Farms Dairy Manure Digester," January 18, 2006. DPNM Biomass Project Final Report, prepared by Agri-Energy and the Dairy Producers of New Mexico, 2005.

[4] The collection efficiency is an assumed value based on engineering judgment. No applicable studies were identified that provided information on methane collection efficiencies achieved using manure digesters (as it relates to collection of entire farm-level emissions).

The second portion of the GHG benefit for offsetting fossil-based electricity generation was estimated by converting the methane to captured in each year to its heat content (in British thermal units [Btu's]) and then multiplying by an energy recovery factor of 17,100 Btu/kW-hr (kilowatt-hour) to estimate the electricity produced (assumes a 25% efficiency for conversion to electricity in an engine and generator set). The CO_2e associated with this amount of electricity in each year was estimated by converting the kW-hr to MW-hr (megawatt-hours) and then multiplying this value by the North Carolina-specific emission factor for electricity production from the I&F (0.542 Mt/MW-hr).

The total GHG benefit was estimated as the sum of both portions of the benefit described above.

Costs

For swine, costs were estimated using annualized costs for the Barham Farm study, which was part of the NCSU technology determinations referenced in the Mark Moser study footnoted below. Data from this study indicate a range of annualized costs from $18 to $45/head to cover installation and operation of a digester and an engine-generator set/flare. Annual operations and maintenance costs from this study were $8/head. These costs provide an estimate for the implementation of digester and energy projects at swine farms toward the upper end of the range for U.S. projects with documented costs.[5] Capital costs per head were about $72 for Barham Farm compared to an average of $52/head for seven U.S. swine digester to energy projects.

For dairies and feedlots, data from the US EPA methane to markets report and Gallo Farms studies referenced below provided an average cost of $450/head for digesters and engine-generator sets (dairies >1,000 head). From the New Mexico Dairy Producers report, capital costs for regional digesters (those serving multiple nearby operations) were estimated to be $190/head. It is not clear based on available data how well regional digesters could be implemented in North Carolina as they require several dairies in close proximity. Therefore, the average of $450/head was used.

The Center for Climate Strategies (CCS) assumed that the 25% Farm Bill grant would be available to each project initiated as a result of this policy.[6] After adjustment of the capital costs, annualized costs per head were estimated assuming a 5% interest rate and a 15-year project life, annual operations and maintenance costs of $38/head were taken from the Gallo Farms Study, and the value of the electricity produced was assumed to be $0.05/kW-hr. Additional incentives to the farmer from the Renewable Energy Production Incentives were not included but could have a small effect on the estimated costs (about $1/Mt$CO_2$e reduced). The annualized per head cost estimates were multiplied by the head of livestock to be controlled in each year to estimate total costs.

Key Assumptions: That the cost data for the studies cited is representative of actual costs; 75% collection efficiency for farm-level methane emissions for the digester. Farm Bill grant will be

[5] Moser, M., "A Dozen Successful Swine Waste Digesters," RCM Digesters, Inc., accessed February 2007 at: http://rcmdigesters.com/images/PDF/ADozenSuccessfulSwineWasteDigesters.pdf

[6] More information on the program is also available at: http://www.rurdev.usda.gov/rbs/farmbill/index.html. The application of this grant incentive was considered a reasonable assumption based on CCS discussions with EPA AgSTAR Program staff; Kurt Roos, personal communication with S. Roe, CCS, March 2007.

available to all projects in subsequent cycles of the Farm Bill through 2020. The $0.05/kWh is the assumed value to the farmer for the electricity produced (either to offset on-farm use or to sell back to the grid); this is a conservative estimate. Higher values for this electricity would translate into a lower cost-effectiveness estimate and a faster return on investment for the farmer.

Key Uncertainties

See key assumptions in the quantification section above.

Additional Benefits and Costs

- *Air & Water Pollution Impacts*—Reductions in emissions of ammonia, volatile organic compounds, and odors (sulfur compounds) are achievable. Reductions occur when anaerobic digesters and energy utilization are used to capture emissions that would have occurred from the lagoon surface. Note that these reductions occur at the lagoon surface and that there is a potential for increased ammonia emissions during application of digester effluent to fields due to high ammonium concentrations, if measures are not taken to avoid these emissions. Ammonia emissions are important in the formation of fine particulate matter and nitrogen deposition to sensitive water sheds. Also, there will be an increase in emissions of nitrogen and sulfur oxides during the combustion of biogas. Both of these pollutants are also fine particulate matter precursors, and oxides of nitrogen are a precursor of ozone.

  Measures to reduce both air and water pollution impacts could include the use of nitrifying/denitrifying systems to reduce the ammonium concentration prior to application. In these systems, ammonium is converted to nitrogen which is released instead of ammonia. (Care must be taken to avoid excessive nitrous oxide emissions, however.) The other option is to identify and produce marketable products from the digester effluent, which would have to be trucked off the farm. The increased GHG emissions associated with transporting any such products have not been factored in to the analysis conducted for this option.

  A study of an anaerobic digester project for a dairy farm[7] demonstrated that these projects can substantially reduce total volatile solids (39.5%) and chemical oxygen demand (38.5%). These reductions translate directly into a lower potential for depletion of dissolved oxygen in natural waters. Although anaerobically digested manure is not suitable for direct discharge to surface or ground waters, these reductions still are significant due to the potential for these wastes to enter surface waters by nonpoint source transport mechanisms. The study also showed that mesophilic anaerobic digestion at an average hydraulic retention time of 29 days reduced the mean densities of the fecal coliform group of enteric bacteria by 99% and fecal streptococcus group by 90%.

- Possible nutrient management benefits for situations where ammonium-rich effluent can be used without excessive ammonia emissions;
- Economic benefits for the digester industry.

[7] "An Evaluation of a Mesophilic, Modified Plug Flow Anaerobic Digester for Dairy Cattle Manure," prepared by Eastern Research Group, prepared for the U.S. EPA AgSTAR Program, July 20, 2005.

Feasibility Issues

- Currently a long return on investment.
- Demand from electric utilities and other entities seeking renewable energy sources.
- Utility barriers including grid interconnection and electricity standby costs charged to the farmer.

Status of Group Approval

Complete.

Level of Group Support

Unanimous.

Barriers to Consensus

None.

AFW-2. Biodiesel Production (Incentives for Feedstocks and Production Plants)

Mitigation Option Description

Use of biodiesel offsets the consumption of diesel fuel produced from oil (fossil diesel). Since biodiesel has a lower GHG content than fossil diesel, overall GHG emissions are reduced. By producing biodiesel in the state for consumption within the state, the highest benefits can be achieved, since the fuel is transported over shorter distances to the end user. This option covers incentives needed to increase biodiesel production in North Carolina.

Note: This option is linked with Transportation & Land Use (TLU) Option 7 on Biofuels. This option seeks to achieve incremental GHG benefits beyond the TLU option by promoting in-state production of biodiesel using feedstocks with greater GHG benefits than the likely business-as-usual (BAU) national production methods. In addition, North Carolina consumption of biodiesel produced in-state will produce better GHG benefits than biodiesel obtained from a national market due to lower embedded CO_2 associated with transportation of biodiesel or its feedstocks from distant sources.

Mitigation Option Design

Goals: Produce enough biodiesel to offset 12.5% of North Carolina's fossil diesel consumption by 2020.

Timing: By 2010, produce enough biodiesel to offset 5% of fossil diesel consumption. By 2020, produce enough biodiesel to offset 12.5% of in-state fossil diesel consumption.

Parties Involved: NCDA&CS, Department of Administration, Motor Carrier Enforcement Division, DENR, Department of Commerce, NC Rural Center, NCSU, North Carolina Agricultural & Technical State University (NCA&T), other state agencies, agricultural associations which represent producers of feedstock, petroleum industry trade groups, and various industry associations.

Other: Not applicable.

Implementation Mechanisms

- Incentives in the form of grants or tax breaks (sales and/or income) for incurred capital costs for feedstock producers (oil crops, methanol/ethanol).
- Streamlined permitting of production facilities. Technical assistance for new producers.
- Incentives and grants for expanded research for oilseed production and processing (including canola and other crops not typically grown in North Carolina).
- Active solicitation of new producers.
- Expanded consumer education to drive demand.
- Expanded producer education to develop skilled workforce.

Related Policies/Programs in Place

- NC Renewable Energy Property tax credit. State income tax credit for 35% of construction costs not to exceed $2.5 million or 50% of tax burden.
- Federal Biodiesel Mixture Tax Credit. Federal excise tax credit for biodiesel mixtures, ranges from $0.50 to $1.00/gallon depending on feedstock.

Type(s) of GHG Reductions

CO_2: Life cycle emissions are reduced to the extent that biodiesel is produced with lower embedded fossil-based carbon than conventional (fossil) diesel fuel. Feedstocks used for producing biodiesel can be made from crops, which contain carbon sequestered during photosynthesis (e.g., biogenic or short-term carbon). The primary feedstocks are vegetable oils (soy, canola, sunflower, algal) and alcohols (either methanol or ethanol). From a recent report (Hill et al., 2006),[8] biodiesel from soybeans contains 93% more useable energy than its petroleum equivalent and reduces life cycle GHG emissions by as much as 41%. Higher oil production potential of different feedstocks (e.g., other oil crops, algae) will likely adjust the life cycle GHG emissions further downward as they are developed as biodiesel sources. Local production of biodiesel also decreases the embedded CO_2e of biodiesel compared to importation of out of state vegetable oil supplies.

Estimated GHG Reductions and Costs (or Cost Savings)

GHG Reduction Potential in 2010, 2020 ($MMtCO_2e$): 0.2, 0.8.

Net Cost per $MtCO_2e$: $56.

Data Sources: Data from the NC Inventory & Forecast were the starting point for quantifying the benefits of offsetting fossil diesel consumption with biodiesel produced within the state (these do not incorporate future reductions in consumption due to TLU options). Fossil diesel consumption estimates are shown in Table H-1 (under BAU).

Table H-1. Projected North Carolina Fossil Diesel Consumption

Year	Diesel Consumption (MMgal/year)
2010	1,470
2020	2,157

The policy design calls for 5% of the fossil diesel consumption to be offset by 2010 from in-state production and 12.5% offset by 2020. Biodiesel production targets are shown in Table H-2.

[8] Hill et al., 2006, "Environmental, economic, and energetic costs and benefits of biodiesel and ethanol biofuels," *Proceedings of the National Academy of Sciences*, 103:11206–11210, July 25, 2006.

Table H-2. Biodiesel Production Targets

Year	Biodiesel Production Needed (MMgal/year)
2010	71
2020	259

By 2010, BAU biodiesel production in the state is expected to be 3 MMgal.[9] By projecting the 2007 to 2010 BAU production growth rate (0 to 3 MMgal/year), the estimated 2020 BAU production level would be 10 MMgal/year. Hence, by 2020, this option would try to increase the production levels to about 249 MMgal/year (see Table H-3).

Table H-3. Additional Biodiesel Production Capacity Needed

Year	Biodiesel Production Needed Beyond BAU (MMgal/year)
2010	68
2020	249

The CO_2e emission factor for fossil diesel used in the inventory and forecast is 10.04 Mt/1,000 gallons. The life cycle fossil diesel emission factor is 12.3 Mt/1,000 gallons (Hill et al., 2006; cited in footnote 8, on the previous page.)

Quantification Methods:

GHG Reductions

A new study on life cycle GHG benefits for biodiesel production and use was used to estimate the CO_2e reductions for this option (Hill et al., 2006). This study covered biodiesel production from soybean production, which is currently the predominant feedstock source for biodiesel production in the United States and is assumed to remain that way for the purposes of this analysis. (It is also the predominant source of vegetable oil production in North Carolina.) Life cycle CO_2e reductions (via displacement of fossil diesel with soybean-derived biodiesel) were estimated by Hill et al. to be 41%. This value is being used by the TLU TWG to estimate the benefit of the biodiesel component of the TLU biofuels option. Hence, this analysis focuses on incremental benefits of in-state feedstocks production with the focus on vegetable oils.

For this option, the incremental benefit of in-state production is derived from the lower embedded GHG content of biodiesel feedstocks (vegetable oil) avoided from having to transport the feedstocks from their likely source region. For this assessment, the likely source regions for soybean or canola oil are the U.S. Midwest or northern plains regions. Using South Dakota as a potential source region, rail transport would require shipments to central North Carolina of about 1,400 miles.[10] Rail fuel consumption is about 400 ton-miles/gallon.[11] The density of vegetable oil

[9] www.eere.energy.gov/states/state_news_detail.cfm/news_id=10298/state=NC; US DOE Energy Efficiency and Renewable Energy Web site, accessed January 16, 2007; Piedmont Biofuels begins operation in late 2006 (1 MMgal/year capacity); one of three plants being built in NC; assume similar capacity for the remaining two and that these will be operational by 2010.

[10] U.S. National Atlas, at http://nationalatlas.gov/natlas/Natlasstart.asp

is about 3,700 tons/MMgal. From these inputs, a GHG emission rate of 130 $MtCO_2$/MMgal oil was calculated.

When combined with the other feedstocks needed to produce biodiesel (e.g., either methanol or ethanol),[12] a gallon of vegetable oil will produce slightly more than one gallon of biodiesel. For the purposes of this estimate, each gallon is assumed to produce one gallon of biodiesel.

In addition to soybean oil, other oil feedstocks included in this analysis include animal oils (yellow grease, poultry fat, lard, and tallow), canola, and algal oils. As mentioned under the feasibility section below, current production of these feedstocks in North Carolina would not meet the goals of the proposed policy (no canola or algal oils are currently produced). Even after substituting canola production for all of the current wheat production in North Carolina, the 2020 production goal would not be met. Hence, it is assumed that technology advances will occur during the policy period that will allow for commercial scale production of algal oil to make up the shortfall (e.g., in the post-2015 period). With sufficient technology advancement, another option could be Fischer-Tropsch biodiesel from cellulose.

For oil sources other than soybean oil, the benefit for substituting in-state biodiesel for fossil diesel is estimated starting with the life cycle soybean emission factor (7,261 $MtCO_2e$/MMgal from the Hill et al. study). As mentioned previously, the benefits of the biodiesel component of the TLU biofuels option is based on displacement with soybean-based biodiesel. Hence, this analysis was designed only to account for the incremental benefit of in-state feedstock (oil) production using GHG preferential feedstocks. These include vegetable oils that produce greater volumes of oil per unit of energy input (e.g., canola), animal fats, and, in the future, algal oils.

Canola produces 127 gallons of oil per acre compared to soybeans at 48 gallons/acre. Assuming canola production energy inputs are not significantly greater than soy, the life cycle emission rate for canola would be 7,261 × 48/127 or 2,744 $MtCO_2e$/MMgal. So the incremental benefit of canola over soy is 7,261 – 2,744 = 4,517 $MtCO_2e$/MMgal.

For animal fats and algal oils, CCS assumes that these have negligible embedded energy. So the incremental benefit over soy equals the life cycle fossil diesel emission factor (EF) (12,306 $MtCO_2e$/MMgal) minus the soybean based EF (7,261 $MtCO_2e$/MMgal), which is 5,045 $MtCO_2e$/MMgal.

To meet the in-state production goals for 2010 and 2020, Table H-4 provides the mix of oil feedstocks assumed in this analysis. The assumed mix relies heavily on new technologies (e.g., algal oil) to produce feedstocks in the post-2010 period. The new production data summarized below exclude BAU production, which is estimated to be 3 MMgal/year in 2010 and 10.3

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[11] U.S. National Atlas, at http://nationalatlas.gov/articles/transportation/a_freightrr.html

[12] While the analysis here focuses on the primary feedstock for biodiesel, vegetable oil, the policy should also promote the production and use of alcohol feedstocks produced from renewable resources (e.g., starch or cellulosic ethanol, renewable methane to methanol).

MMgal/year in 2020.[13] (BAU production is further assumed to be soybean-based with little incremental benefit above the TLU Option 6 benefit).

Table H-4. Assumed Biodiesel Feedstock Mix

Year	Oil Feedstock	Fraction of New Production	MMgal/year Needed*
2010	Soy	0.40	27
2010	Canola	0.10	7
2010	Animal	0.50	34
2010	Algal	0.00	–
		2010 Total	**68**
2020	Soy	0.12	30
2020	Canola	0.25	62
2020	Animal	0.20	50
2020	Algal	0.43	107
		2020 Total	**249**

* Excludes BAU production estimated to be 3 MMgal/year in 2010 and 10.3 MMgal/year in 2020.

GHG reductions were estimated by multiplying the production of each oil feedstock by the applicable incremental benefit (e.g., by oil type). Total reductions in each year were estimated by summing the incremental benefit for each oil type.

Costs

Costs were estimated using information from an analysis of biodiesel production costs from the United State Department of Energy (US DOE).[14] The value of incentives needed is assumed to be equivalent to the difference in the costs of producing fossil diesel and soy-based biodiesel ($0.34/gallon). This value is very close to the incentive offered in a State of Missouri incentives program.[15] This program offers production incentives of $0.30/gallon to producers up to 15 million gallons of production/year. The incentive grants last for 5 years.

CCS assumed a similar incentive structure and that these would cover the costs of all grants or tax incentives associated with this policy (all other implementation mechanisms are assumed to be achieved within existing programs). The cost estimates are based on multiplying the amount of biodiesel produced in each year by the production incentive. This assumes that all production

[13] See www.eere.energy.gov/states/state_news_detail.cfm/news_id=10298/state=NC, US DOE Energy Efficiency and Renewable Energy; Piedmont Biofuels begins operation in late 2006. One of three plants being built. Assume similar capacity for the remaining two to be operational by 2010. After 2010, assumes BAU growth is at the estimated 2007–2010 growth rate (0.7 MMgal/year).

[14] See www.eia.doe.gov/oiaf/analysispaper/biodiesel/index.html; accessed January 2007.

[15] Information on the Missouri Program: www.newrules.org/agri/mobiofuels.html#biodiesel, accessed January 2007.

occurs at production facilities of less than 15 million gallons/year. The production incentive runs out after 5 years of production.

Key Assumptions: Life cycle GHG emission factors utilized/derived for this analysis are representative for each feedstock and for fossil diesel. Production incentives offered by this option are sufficient to drive production of GHG-superior feedstocks (e.g., superior to soybeans) and to increase the level of research and development needed for non-crop based feedstocks (e.g., algal biodiesel, Fischer-Tropsch biodiesel).

Key Uncertainties

Pending.

Additional Benefits and Costs

- Additional markets for oilseed crops and animal fats.
- Economic growth from locally produced fuels.

Feasibility Issues

Current production of biodiesel feedstocks in North Carolina are provided in Table H-5.[16]

Table H-5. Current Biodiesel Feedstock Production in North Carolina

Feedstock	Million gallons per year
Soy oil	60.5[17]
Canola oil	0
Yellow grease	10
Poultry fat	21
Lard	21
Tallow	2
Total Current Feedstocks	**114.5**

By converting all North Carolina wheat to canola production, another 66 MMgal/year could be produced,[18] yielding a total of about 180 MMgal/year. Given that the policy requires about 250 MMgal/year by 2020, these data show the importance of additional research and development and production incentives for other non-crop sources of biodiesel feedstock oil. These include production of oil from algae and Fischer-Tropsch biodiesel from cellulose.

Status of Group Approval

Complete.

[16] Henry Tsai, economist, NCSU Solar Center, 2004 slideshow, "Implications of Rising Energy Cost on the Economy: 3 Different Perspectives."

[17] NC Biomass Resource Inventory 2003. This oil production figure was calculated based on 43,200,000 bushels of soy grown in North Carolina.

[18] Kurt Creamer, North Carolina State University, personal communication with S. Roe, CCS, January 16, 2007.

Level of Group Support

Unanimous.

Barriers to Consensus

None.

AFW-3. Soil Carbon Management

Mitigation Option Description

Use of conservation tillage, no-till methods, cover cropping, and other soil management practices can increase the level of organic carbon in the soil, which sequesters carbon dioxide. In addition, some practices lower fossil fuel consumption through less intensive equipment use. Other practices, such as the application of bio-char can also increase the level of soil carbon and improve the soil.

Another element of this option is the promotion of certified organic production techniques. A number of studies have found that organic production of row crops result in GHG benefits, including higher levels of soil organic carbon, relative to conventional production methods. This option is designed to increase the acreage using soil management and production practices that lead to higher soil carbon content and other GHG benefits.

Mitigation Option Design

Goals: By 2020, apply soil management practices on 50% of cultivated lands that currently do not use these techniques. Also, identify and promote organic production techniques that have been demonstrated in North Carolina to achieve net GHG benefits.

Timing: By 2010, apply soil management practices on 20% of acres that currently do not use these practices. Achieve an increase to 50% of these acres by 2020. By 2010, complete a systematic assessment of organic cultivation systems for North Carolina crops and identify those that achieve net GHG benefits. Initiate programs to promote these organic cultivation methods through 2020.

Parties Involved: NC Department of Agriculture (Center for Environmental Farming Systems [CEFS]), NC DENR, NCSU (College of Agricultural and Life Sciences [CALS], and College of Natural Resources [CNR]), NC Extension, and other agricultural organizations and associations.

Other: Studies in North Carolina have found the potential to sequester one ton of carbon per acre through conservation tillage/no-till practices over a 6-year period[19] (equivalent to about 3.3 $MtCO_2e$/acre). Studies in California[20] and Pennsylvania[21] have shown that certified organic production methods of row crops sequester dramatically more carbon than conventional practices. Both studies independently concluded that fully tilled organic production can sequester

[19] Available at http://southeastfarmpress.com/news/030106-Naderman-conservation/

[20] Source: *Conservation tillage and cover cropping influence soil properties in San Joaquin Valley cotton-tomato crop,* by Jessica J. Veenstra, William R. Horwath, Jeffrey P. Mitchell and Daniel S. Munk. California Agriculture Journal, July-Sept. 2006.

[21] "The Rodale Institute Farming Systems Trial 1981 to 2005: Long Term Analysis of Organic and Conventional Maize and Soy-bean Cropping Systems," pp15–30, in *Long Term Field Experiments in Organic Farming,* edited by J. Rauppe, C. Perkrun, M. Oltmanns, U. Kopke. ISOFAR—International Society of Organic Agricultural Research, Verlaug Publishing, Berlin, 2006.

1,000 lb per acre per year.[22] Soil carbon accumulations up to 28,000 lb per acre were observed in the 25-year field trial performed at the Rodale Institute.

A recent study in the United Kingdom[23] found that some organic production techniques have higher energy inputs or land requirements than conventional techniques (sometimes due to lower yields, longer production cycles for livestock like poultry). Because increases in soil carbon content do not fully reflect crop production cycle GHG emissions (due to changes in tillage practices and application of chemicals among other things), research and pilot studies will be needed to determine which organic cropping systems in North Carolina achieve net GHG benefits (see Feasibility Issues section below).

Implementation Mechanisms

- Increase North Carolina Agriculture Cost Share funding to include additional acreage in no-till and organic farming techniques.
- Create a Cost Share program to help producers through the process of organic certification.
- Expand educational programs through NCCES on conservation tillage and certified organic production techniques.
- Research the organic production systems suitable for North Carolina that produce net GHG benefits. Actively promote penetration of organic production methods within these systems.
- Research the availability and effectiveness of bio-char application.
- Research the need for infrastructure to facilitate in-state farmers moving their organically produced goods to market.
- Incentives in the form of grants, tax breaks, or loan guarantees for development of infrastructure needed for certified organic commodities and crops.

Related Policies/Programs in Place

- NC Agriculture Cost Share Program for no-till; $125/acre with a 120-acre cap for switching to no-till for 5 consecutive years.
- NRCS cost share programs.

Type(s) of GHG Reductions

- **CO_2:** Reducing tillage and soil disturbance slows the breakdown of plant material on the soil surface and in the root zone, accelerating the microbial processes that stabilize carbon and protecting carbon from oxidation, inhibiting the release of carbon back into the atmosphere. Depending on how the adoption of conservation tillage and organic production methods affects the overall crop production cycle, additional CO_2 reductions can occur through lower fossil fuel consumption in farm equipment. Note that some studies have shown higher fuel consumption using organic techniques than conventional production. Also, organic

[22] Source: Interview with Dr. Paul Hepperly, Rodale Institute, February 8, 2007.

[23] *Environmental Impacts of Food Production and Consumption*, Manchester Business School, prepared for the Department for Environment, Food and Rural Affairs, December 2006, http://www.defra.gov.uk/science/project_data/DocumentLibrary/EV02007/EV02007_4601_FRP.pdf

production methods reduce GHG emissions associated with the production, transport, and application of pesticides, herbicides, and other chemical treatments.

- **N_2O:** To the extent that fossil fuel consumption is lowered through the cultivation methods implemented under this policy, N_2O emissions from fuel combustion will be lowered. *It is important to note that research also indicates the potential for higher N_2O emissions as soil organic carbon levels increase* (see Feasibility Issues Section below).
- **CH_4:** To the extent that fossil fuel consumption is lowered through the cultivation methods implemented under this policy, CH_4 emissions from fuel combustion will be lowered.

Estimated GHG Reductions and Costs (or Cost Savings)

GHG Reduction Potential in 2010, 2020 ($MMtCO_2e$): 0.2, 0.1.

Note: The GHG reductions above and costs below do not reflect the organic production incentives elements of this option. Because agricultural soils will only accumulate carbon up to a certain level before tapering off, the GHG benefit decreases in the post-2020 period to about 0.05 $MMtCO_2e$/year after 2025. The remaining benefit, which is permanent, is associated with lower fossil fuel consumption.

Net Cost per $MtCO_2e$: –$5.

Data Sources: Agricultural soil carbon accumulation levels were taken from a 2006 study by Naderman et al.[24] This study found a range of soil carbon accumulation in different North Carolina cropping systems of 1,000–3,000 lb/acre. These accumulations occurred following a period of six consecutive years of no-till farming. Data on current (2004) acres of cropland where conservation till/reduced till practices are employed were taken from the Conservation Technology Information Center (CTIC).[25] These data show that North Carolina had 4,234,965 planted acres in 2004. In 2004, 2,292,104 acres were cultivated using conservation tillage or reduced tillage methods.

The reduction in fossil diesel fuel use from the adoption of conservation tillage methods is 3.5 gallons/acre.[26] From the NC Inventory & Forecast, the fossil diesel GHG emission factor is 8.37 $MtCO_2e$/1,000 gallons.

Adoption of conservation tillage/no-till practices are estimated to result in a cost savings for the grower. Work by NCSU on applying these practices to cotton growing in North Carolina resulted in a range of cost savings from about $3 to $14 per acre per year.[27] CCS used the low end of the range as a conservative estimate of cost savings for this policy option. An older cost study for

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[24] Naderman, G., B.G. Brock, G.B. Reddy, C.W. Raczkowski, *Long Term No-Tillage: Effects on Soil Carbon and Soil Density Within the Prime Crop Root Zone*, Project Report, NCSU, January 2006.

[25] 2004 CTIC data provided by Paul Sherman of the NC Farm Bureau, February 2006.

[26] Reduction associated with conservation tillage compared to conventional tillage, at http://www.ctic.purdue.edu/Core4/CT/CRM/Benefits.html, accessed August 2006.

[27] $3–$14/acre savings dependent on comparison of no-till to either strip till or conventional tillage. From: Economic Comparison of Three Cotton Tillage Systems in Three NC Regions, S. Walton and G. Bullen, NCSU, at www.ces.ncsu.edu/depts/agecon/Cotton_Econ/production/Economic_Comparison.ppt, accessed February 2007.

no-till versus conventional tillage methods for corn and soybeans in North Carolina showed significant cost savings for no-till methods for most cropping systems and tillage methods ($5–$20/acre).[28] Given that these were based on 1981 data (including fuel prices), the cost savings in today's dollars would be much larger. No additional cost benefits were incorporated for the cost share programs noted above.

Quantification Methods: Based on the policy design parameters, the schedule for acres to be put into conservation tillage/no-till cultivation are shown in Table H-6. The midpoint of the estimated range for carbon sequestration (2,000 lb/acre) in North Carolina agricultural soils was used to estimate the total amount of carbon to be sequestered. Based on the Naderman et al. study referenced above, it was further assumed that this additional carbon would be sequestered in the soil over a period of six years (after 6 years no further carbon is stored). The resulting annual carbon accumulation rate was converted into its CO_2 equivalent yielding 0.55 $MtCO_2$/acre-year.

To estimate carbon stored each year, the annual accumulation rate was multiplied by the number of acres in the policy program each year. After 6 years, the crop acres that entered the program were assumed to not store additional carbon. Results are shown in Table H-6.

Additional GHG savings from reduced fossil fuel consumption were estimated by multiplying the fossil diesel emission factor and diesel fuel reduction per acre estimate provided above. Results are shown in Table H-6 along with a total estimated benefit from both carbon sequestration and fossil fuel reductions.

Costs were estimated by multiplying the estimated savings per acre cited above ($3) by the number of acres in the program each year. The effects of other existing incentive programs were not taken into account in these estimates.

Key Assumptions:

These include the of the assumed carbon sequestration potential is representative across all of the crop systems to which the policy is applied; a 6-year period for accumulating the soil carbon; no additional significant accumulation of soil carbon after 6 years; any potential increase in N_2O emissions (see Feasibility Section below) is not large enough to significantly effect the estimated benefits; the cost savings is a representative average of savings to be achieved across all crop systems.

[28] *No-Till Crop Production Systems in North Carolina—Corn, Soybeans, Sorghum, and Forages*, North Carolina Agricultural Extension Service, date unknown, accessed February 2007, at www.ag.auburn.edu/aux/nsdl/sctcsa/Proceedings/1981/1981_SCTCSA.pdf.

Table H-6. Assumed Schedule for Adoption of Conservation Tillage/No-Till Practices and Associated Benefits

Year	Acres in Program	Acres still accumulating carbon	$MMtCO_2e$ Sequestered	Diesel Saved (1,000 gal)	Diesel GHG avoided ($MMtCO_2e$)	Total $MMtCO_2e$ saved
2007	97,393	97,393	0.054	341	0.0029	0.0568
2008	194,786	194,786	0.108	682	0.0057	0.1137
2009	306,788	306,788	0.170	1,074	0.0090	0.1791
2010	389,572	389,572	0.216	1,364	0.0114	0.2274
2011	448,008	448,008	0.248	1,568	0.0131	0.2615
2012	506,444	506,444	0.281	1,773	0.0148	0.2956
2013	564,880	467,487	0.259	1,977	0.0166	0.2757
2014	623,316	428,530	0.238	2,182	0.0183	0.2558
2015	681,752	374,964	0.208	2,386	0.0200	0.2279
2016	740,188	350,615	0.194	2,591	0.0217	0.2161
2017	798,624	350,615	0.194	2,795	0.0234	0.2178
2018	857,059	350,615	0.194	3,000	0.0251	0.2195
2019	915,495	350,615	0.194	3,204	0.0268	0.2212
2020	973,931	350,615	0.194	3,409	0.0285	0.2229
2021	973,931	292,180	0.162	3,409	0.0285	0.1905
2022	973,931	233,744	0.130	3,409	0.0285	0.1581
2023	973,931	175,308	0.097	3,409	0.0285	0.1257
2024	973,931	116,872	0.065	3,409	0.0285	0.0933
2025	973,931	58,436	0.032	3,409	0.0285	0.0609
2026	973,931	0	0.000	3,409	0.0285	0.0285
2027	973,931	0	0.000	3,409	0.0285	0.0285
2028	973,931	0	0.000	3,409	0.0285	0.0285
2029	973,931	0	0.000	3,409	0.0285	0.0285
2030	973,931	0	0.000	3,409	0.0285	0.0285

Key Uncertainties

See “key assumptions” in the previous section. Note that the benefits and costs of the application of bio-char to agricultural soils have not been included in this analysis. Within the period of analysis for this policy, bio-char application could become another element of this program to increase soil carbon levels in agricultural soils.

Additional Benefits and Costs

Organic production under offers considerable economic market benefits: Certified producers are receiving premium prices for their harvests.

The dramatic increases in soil carbon with certified organic production methods offer further benefit in periods of drought or extreme rain. The Rodale Farming Systems Trial has quantified

superior crop production during droughts, compared to conventional no-till production, because soils in the organic plots captured more water and retained more of it in the crop root zone than in the conventional no-till plots. During torrential rains, water capture in the organic plots was approximately 100% higher than in conventional no-till plots.[29]

Feasibility Issues

The goal of expanding organic production by 10% is modest and feasible, and has been easily beaten by our foreign competitors: During the period of 2002 to 2006, China's certified organic acreage grew 8,650% (from 40,000 to 3.5 million); Uruguay, 58,285% (1,300 to 759,000); Chile, 1,200% (3,000 to 39,000); and Mexico 243% (86,000 to 295,000). The growth in Uruguay, Chile, and Mexico was entirely driven by market demand, not subsidies or policies.[30]

Our acreage goal has been easily achieved and surpassed by other states in the United States: From 2000 to 2005, California's total certified organic acreage of cropland grew from 141,000 to 223,000, a more than doubling.[31]

Research has indicated a potential for increased N_2O emissions as soil organic carbon levels increase.[32] Additional study and field work on North Carolina cropping/soil systems will be needed to verify the GHG reduction potential estimated in this policy analysis for no till cultivation.

More importantly, additional study of organic production systems applicable to North Carolina is needed to determine full crop production cycle GHG benefits. Known benefits for organic production systems include

- *CO_2 Capture*—cover crops used in organic production actively capture atmospheric CO_2, and full-tilling incorporates it into the soil deeper and faster than conventional no-till. Organic production methods cause crops to grow more root mass, deeper than with conventional methods, creating deeper accumulation of soil carbon, allowing for greater long-term accumulation.[33]
- *Avoided CO_2 Release*—by using animal manure, compost, and cover crops as fertilizers, certified organic production methods do not oxidize the soil carbon as nitrogen fertilizer does. The lime applied to adjust the pH actually releases CO_2.[34]

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[29] Source: *"The performance of organic and conventional cropping systems in an extreme climate year,"* D.W. Lotter, R. Seidel, and W. Liebhardt, Rodale Institute, American Journal of Alternative Agriculture, September 2003, 18(3):146–154(9).

[30] Source: *"The World of Organic Agriculture: Statistics & Emerging Trends 2006,"* by Helga Willer and Minou Yussefi, IFOAM (International Federation of Organic Agriculture Movements), 2006, Bonn, Germany. http://orgprints.org/5161/01/yussefi-2006-overview.pdf

[31] Source: Interview with Catherine Greene, USDA Economic Research Service, February 8, 2007.

[32] Li et al., "Carbon Sequestration in Arable Soils is Likely to Increase Nitrous Oxide Emissions, Offsetting Reductions in Climate Radiative Forcing" *Climate Change*, (2005) 72:321–338.

[33] Source: Interview with Dr. Paul Hepperly, Rodale Institute, February 8, 2007.

[34] Ibid.

- *Avoided GHG Emissions in Production of Inputs*—nitrogen fertilizer, pesticides, and herbicides used in conventional agriculture (including conventional no-till), require process energy and petrochemicals in their production. Organic production methods grow their fertilizers (or use manures and composts), and control weeds and pests in ways that have a lower life cycle energy cost.[35]
- *Greater Overall Soil Carbon and GHG Benefits*—No-till conventional uses more energy and produces more CO_2 than full-tillage organic row crop production with cover crops. The energy burned in diesel fuel is less than the embodied energy in the avoided fertilizer and lime.[36]

Recent study in the United Kingdom found that in many but not all organic production systems that net GHG emissions were reduced.[37] Organic farming's weaknesses were identified as (1) similar inputs into the farm including manufacture/operation of machinery and packaging; (2) in some cases, significantly lower yields resulting in higher GHG emissions per ton of product; and (3) slower maturing of animals (more GHG per ton product).

It will be important for North Carolina to study and identify the organic production systems best suited to the state and that produce net GHG benefits. In conjunction with implementation of this policy NCSU's Agronomy Division, Soil Testing Service, can provide the service of soil carbon measurements on the soil samples certified producers are already required to submit.

Status of Group Approval

Complete.

Level of Group Support

Unanimous.

Barriers to Consensus

None.

[35] Environmental, Energetic and Economic Comparisons of Organic and Conventional. Farming Systems, David Pimentel, Paul Hepperly, James Hanson, David Douds, Rita Seidel. *BioScience*, 55(7) July 2005.

[36] Source: Interview with Dr. Paul Hepperly, Rodale Institute, February 8, 2007.

[37] Melchett, P., "One planet agriculture—the strengths and weaknesses of organic food and farming", Soil Association Conference 2007, January 26, 2007, http://www.soilassociation.org.uk/Web/SA/saweb.nsf/cfff6730b881e40e80256a6a002a765c/902f12def991d13a80256f9c005e300e/$FILE/conference_melchett.pps

AFW-4a. Preservation of Working Lands—Agricultural Land

Mitigation Option Description

Reduce the rate at which existing crop and pasture are converted to developed uses. The carbon sequestered in soils and aboveground biomass is much higher in croplands than in developed land uses. Policies are needed to preserve working farms and forests (see AFW-4b) from unwise and unplanned development. This option should be seen as a companion measure to TLU-1a (Land Development Planning).

Mitigation Option Design

State and national programs have been established to protect farm communities from conversion to development. Funding state farmland preservation programs will help meet goals and act as a needed match to national programs. Programs are being investigated that help farmers transition lands to beginning farmers.

Goals: Reduce the rate at which agricultural lands are converted to developed use by 50% by 2020 from current levels.

Timing: By 2010, reduce the rate of conversion by 20% from current levels. By 2020, reduce the rate of conversion by 50%.

Parties Involved: NCDA&CS, NC Farm Bureau, NCDFR, United States Forest Service (USFS), NC Department of Forest Resources (NCDFR), NCSU, and NC Farm Transition Network.

Other: North Carolina lost 5,500 farms and 300,000 acres between 2003 and 2006.[38]

Implementation Mechanisms

- Increased funding for state farmland preservation programs.
- Increased public education on the benefits of preserving agricultural land.
- Inclusion in voluntary programs such as NC Agriculture Cost Share.
- Increased funding from General Funds.
- Increase funding for Agricultural Development and Farmland Preservation Trust Fund (protects forest and farmlands).
- Farm Bill Conservation Title—USDA's Environmental Quality Incentives Program (EQIP), USDA's Conservation Reserve Program (CRP), and USDA's Conservation Reserve Enhancement Program (CREP).
- Encourage counties to construct County Farmland Protection Plans in order to identify and plan to protect their farm and forestland production areas.

[38] Max Merrill, NCDA&CS, personal communication with S. Roe, CCS, March 15, 2007.

- Engage local governments and nongovernmental organizations on recruiting farmers to take part in protection programs and in developing funding mechanisms to support the plans.

Related Policies/Programs in Place

- Agricultural Development and Farmland Preservation Trust Fund.
- Present Use Tax Valuation.
- North Carolina Conservation Tax Credit.
- Farm and Ranchlands Protection Program.
- Forest Legacy Program.
- EQIP, Waste Reduction Partners (WRP), CRP, CREP, and USDA's Wildlife Habitat Incentives Program (WHIP).
- Million Acre Initiative.

Type(s) of GHG Reductions

- **CO_2:** Conservation of agricultural lands retains the ability of the land to sequester carbon in soil and biomass. Also, emissions are indirectly reduced to the extent that development patterns are influenced and vehicle miles traveled (VMT) are reduced (see TLU Option 1a).
- **CH_4 and N_2O:** Are also indirectly reduced as VMT are reduced.

Estimated GHG Reductions and Costs (or Cost Savings)

GHG Reduction Potential in 2010, 2020 ($MMtCO_2e$): 0.2, 0.3.

Net Cost per $MtCO_2e$: $114.

Note: The reductions and cost per Mt estimated for this option only refer to the direct benefits and costs associated with the estimated loss of soil carbon from agricultural soils due to development. They do not include the indirect benefits of more efficient development patterns that could result from this option (see TLU Option 1a).

Data Sources:

The annual rate of agricultural land conversion in North Carolina is 100,000 acres per year based on information from Max Merrell, Environmental Specialist with NCDA&CS. This is very close to another estimate of 101,600 acres/year taken from a 2001 study.[39] The typical level of soil carbon in agricultural soils in North Carolina was taken from a 2002 study of Piedmont soils (0.017 million metric tons of carbon [MMtC]/1,000 acres for the top 8 inches of soil).[40] The cost

[39] 1992–1997 rate of conversion from Commission on Smart Growth, *Growth Management and Development: Findings and Recommendations*, Fall 2001, at www.eatsmartmovemorenc.com/resources/documents/aces/aces_smartgrowth.pdf

[40] Franzluebbers, A.J., B. Grose, L.L. Hendrix, P.K. Wilkerson, B.G. Brock, "Surface-Soil Properties in Response to Silage Intensity under No-Tillage Management in the Piedmont of North Carolina," presented at the 25th Southern Conservation Tillage Conference for Sustainable Agriculture, Auburn, AL, June 24–26, 2002, at www.ars.usda.gov/SP2UserFiles/Place/66120900/SoilManagementAndCarbonSequestration/2002ajfP02.pdf. The data associated with high intensity crop tillage were used to develop the value used in this analysis.

of establishing conservation easements on agricultural lands surrounding developing areas was taken from NRCS information on the Farm Preservation Program (FPP).[41] The FPP provides cost share to establish conservation easements on agricultural lands (up to 50% cost share). Because the available data were taken from a 2001 summary for North Carolina, CCS used the high end of the range of costs per acre to represent potential costs in 2007 dollars ($2,069/acre). This cost is nearly identical to the nationwide average determined by the American Farmland Trust ($2,000/acre).[42]

Quantification Methods:

GHG Benefits

Studies are lacking on the changes in below and aboveground carbon stocks when agricultural land is converted to developed uses. For some land use changes, carbon stocks could be higher in the developed use relative to the agricultural use (e.g., parks). In other instances, carbon stocks are likely to be lower (graded and paved surfaces). CCS assumed that the agricultural land would be developed into typical tract-style suburban development. It was further assumed that 50% of the land would be graded and covered with roads, driveways, parking lots, and building pads. The final assumption was that 75% of the soil carbon in the top 8 inches of soil for these graded and covered surfaces would be lost and not replaced. CCS assumed no change in the levels of aboveground carbon stocks.

The benefit in each year was determined by (1) determining the amount of land protected in each year by multiplying the annual rate of agricultural land lost by the percent of agricultural land protected; (2) multiplying the soil carbon content on the protected land by 50% (representing graded and covered areas) and by 75% (fraction of soil carbon lost); and (3) converting the soil carbon lost to CO_2 by multiplying by 44/12. Table H-7 provides a summary of the estimates for each year.

[41] NRCS, 2001. Range of Farmland Protection Program costs for easements, range $1,660–$2,059/acre, average $1,885/acre; Farmland Protection Program, NC Summary, December 2001, at www.nrcs.usda.gov/programs/frpp/StateFacts/NC_2001.pdf

[42] American Farmland Trust, A National View of Agricultural Easement Programs, at http://www.aftresearch.org/PDRdatabase/NAPidx.htm

Table H-7. Land Protection Schedule and Associated Benefits

Year	% of Conversion Reduced	Ag Acres Protected	$MMtCO_2e$ Saved
2007	0	0	0.00
2008	10	10,160	0.07
2009	10	10,160	0.07
2010	20	20,320	0.13
2011	20	20,320	0.13
2012	30	30,480	0.19
2013	30	30,480	0.19
2014	30	30,480	0.19
2015	30	30,480	0.19
2016	40	40,640	0.26
2017	40	40,640	0.26
2018	40	40,640	0.26
2019	50	50,800	0.32
2020	50	50,800	0.32
	Totals	**406,400**	**2.6**

Costs

To estimate program costs in each year, CCS multiplied the estimated agricultural acres protected from development by the conservation cost ($2,069/acre) and an assumed cost share of 50%. This cost share is assumed to be available from the NRCS or other sources (e.g., city or county governments, or non-government organizations). The resulting cost-effectiveness is $114/Mt. This estimate only accounts for the direct reductions associated with soil carbon losses estimated above and does not include potentially much larger indirect benefits associated with reductions in VMT (see TLU Option 1a).

Note that the availability of this cost share is a significant assumption for this policy option, since the number of acres to be protected is substantially higher than the average protected during the 1996–2001 period (about 200 acres/year). Without the cost share, the cost-effectiveness would be twice the value presented here.

Key Assumptions: No change in aboveground carbon stocks; 75% loss of soil carbon on 50% of developed land; 50% cost share available from NRCS, city/local governments, or other sources.

Key Uncertainties

As described above, these include the estimated above and belowground carbon stocks for agricultural and developed land uses and the availability of cost share programs to offset the costs of purchasing conservation easements.

Additional Benefits and Costs

- **Human and Social Issues:** Protection of working lands will provide a better quality of life for the citizens of North Carolina and protect its rural landscapes and heritage. Protection of

these lands will also help to preserve lands for producing food, fuel, and other resources needed by society.

- **Environmental Issues**: (1) Working lands provide environmental services to the citizens of North Carolina by providing clean air, clean water, and wildlife habitat that all North Carolinians enjoy. It has been well documented that impervious surfaces and development has a detrimental affect on our natural resources. (2) The Preservation of working lands can also suppress suburban sprawl and help decrease transportation related emissions.
- **Economic Issues:** (1) Cost of community service studies show that residential development does not pay for itself in taxes. However, working lands require an average of .34 cents in services for every $1 collected from local governments. This is a net gain for local and county budgets (American Farmland Trust);. (2) Agriculture is the number one industry in North Carolina at $68 billion in total revenue.

Feasibility Issues

None noted.

Status of Group Approval

Complete.

Level of Group Support

Unanimous.

Barriers to Consensus

None.

AFW-4b. Preservation of Working Lands – Forest Land

Mitigation Option Description

Reduce conversion of forest lands to non-forest cover such as development and to reduce the rate at which forested tracts are becoming parcelized and/or fragmented. Developed areas contain lower amounts of biomass and its associated carbon. These areas also sequester less carbon dioxide than forested areas. When landowners do not have the incentive to retain their ownership, they often not only sell for development, but they may sell a forested tract by smaller parcels which may then be too small to allow forest management to be practical. On tracts too small and fragmented to be managed, the goals of AFW 9&10 cannot be achieved. Managed stands sequester carbon faster than non-managed stands. Also, harvested products from managed stands sequester carbon long term in durable products. Finally, biomass used for energy purposes can offset fossil fuel use.

Mitigation Option Design

North Carolina is losing on average 61,390 acres of productive forest each year over the last 30 years to development and a lack of post-harvest regeneration. This amounts to a loss of about 10% of the state's forestland since 1974, or about a 0.36% annually compounded loss.

Goals: Reduce the rate of conversion by 10% by 2010 and 25% by 2020.

Timing: See above.

Parties Involved: NCDFR, NC Extension, NCSU CNR, NC Forestry Association, and NC Woodlands.

Other: The conversion of forested lands to developed uses is not consistent; between 1984 and 1990, there was actually an increase in the timberland area of 260,000 acres. This offers hope that one might reverse the overall trends in forest losses.

Implementation Mechanisms

- Use valuation, perhaps subsidize where use value is same as commercial value.
- Higher value to forestry, see AFW 9&10.
- Better funding for existing forest conservation easement programs
- Retain Forestry Present Use Valuation

Related Policies/Programs in Place

- North Carolina Conservation Tax Credit Program
- North Carolina Forest Legacy Program

Type(s) of GHG Reductions

- Prevention of emissions from forest conversions and retention of soil carbon

- Continued forest growth and sequestration on protected acres
- Carbon sequestration in the form of durable wood products and fossil fuel offsets from forest based energy (not quantified)

Estimated GHG Reductions and Costs (or Cost Savings)

GHG Reduction Potential in 2010, 2020 ($MMtCO_2e$): 1.7, 4.3.

Cumulative GHG Reduction Potential ($MMtCO_2e$, 2007–2010): 35.5

Net Cost per $MtCO_2e$: $3

Data Sources: "US Forest Service Methods for Calculating Forest Ecosystem and Harvested Carbon with Standards Estimates for Forest Types of the US," General Technical Report NE-343 (also published as part of the US DOE Voluntary GHG Reporting Program). Data from the USFS Forest Inventory Program were used to determine the average annual rate of forest loss over the last 30 years. North Carolina Conservation Tax Credit Program (http://www.enr.state.nc.us/conservationtaxcredit/pages/creditperformance.html). North Carolina Forest Legacy Program internal Forest Legacy documents provided by Dr. Mark Megalos and http://www.dfr.state.nc.us/tending/tending_legacyoverview.htm.

Quantification Methods: Carbon savings were estimated as the portion of carbon that would be lost as a result of forest conversion to developed uses. A carbon savings coefficient was calculated from standard carbon stock coefficients for a 65-year-old loblolly-shortleaf pine stand in the southeastern United States. Table H-8 provides these carbon stock data in units of both metric tons of carbon per acre (MtC/acre) and metric tons of carbon per hectare (MtC/ha). It was assumed that 95% of the carbon stocks would be lost in the event of forest conversion to developed uses with no appreciable carbon sequestration in soils or biomass following development.

Table H-8. Carbon Stocks for 65-year-old Loblolly-Shortleaf Pine in the Southeastern United States

Forest Carbon Pool	MtC/acre	MtC/ha
Live tree	40.3	99.6
Standing dead tree	1.2	2.9
Understory	1.2	2.9
Down dead wood	3.3	8.1
Forest floor	5.8	14.4
Soils	28.2	69.6
Total	**79.9**	**197.5**

Source; USFS GTE NE-343, Table B39

Carbon savings were calculated using a gradual phase in of the goal levels. A 2.5% reduction in annual forest conversion rates was assumed in 2007 (i.e., conversion did not occur on 1,535 acres of forests as a result of the program). The number of acres that were not converted to developed uses was increased incrementally by 2.5% per year until 2010, at which point 6,139 acres of forest were maintained instead of being converted to development. From 2010 to 2020,

the number of acres of forest not converted each year phases in more gradually (i.e., by 1.5% each year), such that by 2020, 15,348 acres of forest is maintained instead of converted. Each year, the number of acres estimated to remain in forest as a result of the program was multiplied by 95% of the total carbon stock shown in Table H-8.

Annual carbon savings over the time period 2007–2020 are shown in Figure H-1 and cumulative carbon savings are shown in Figure H-2.

Figure H-1. Annual Carbon Savings Avoided from Forest Conversion

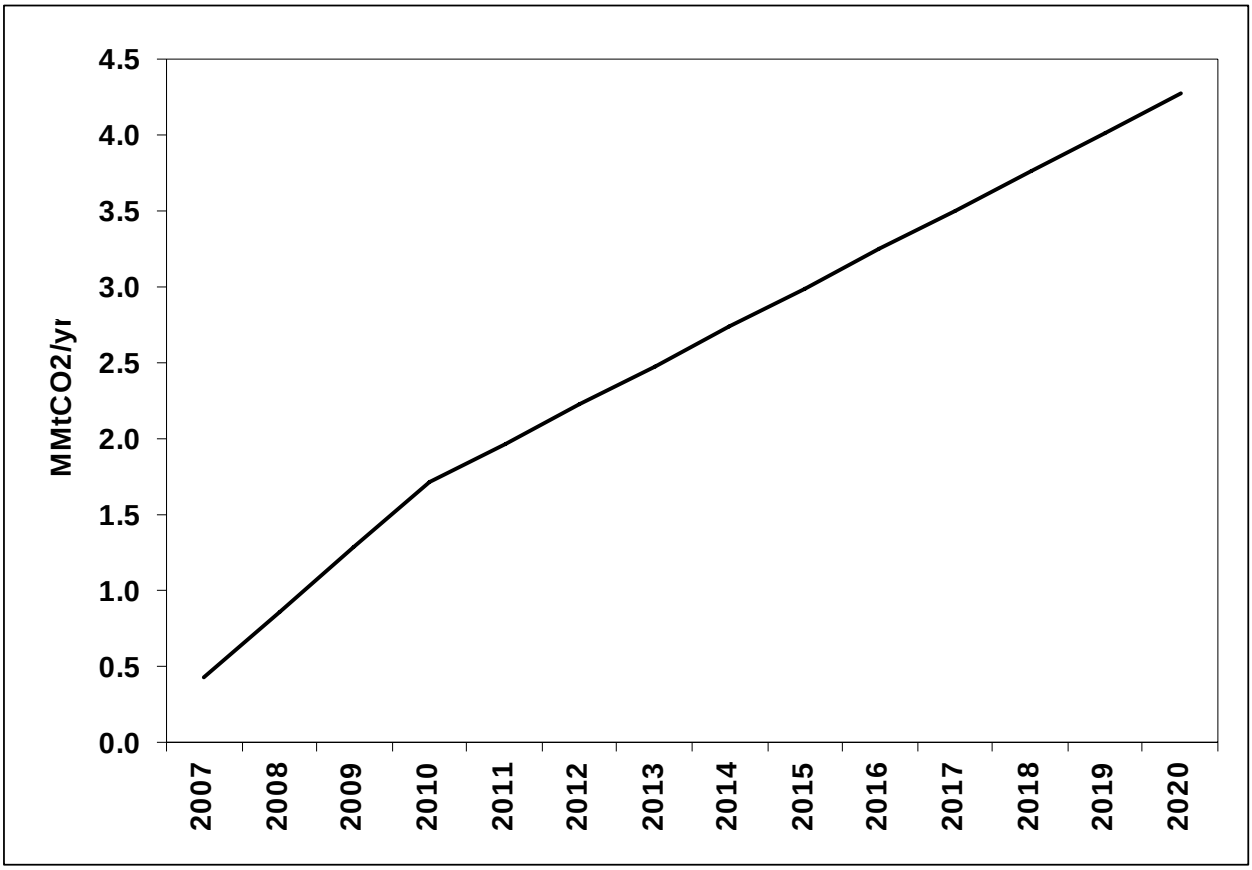
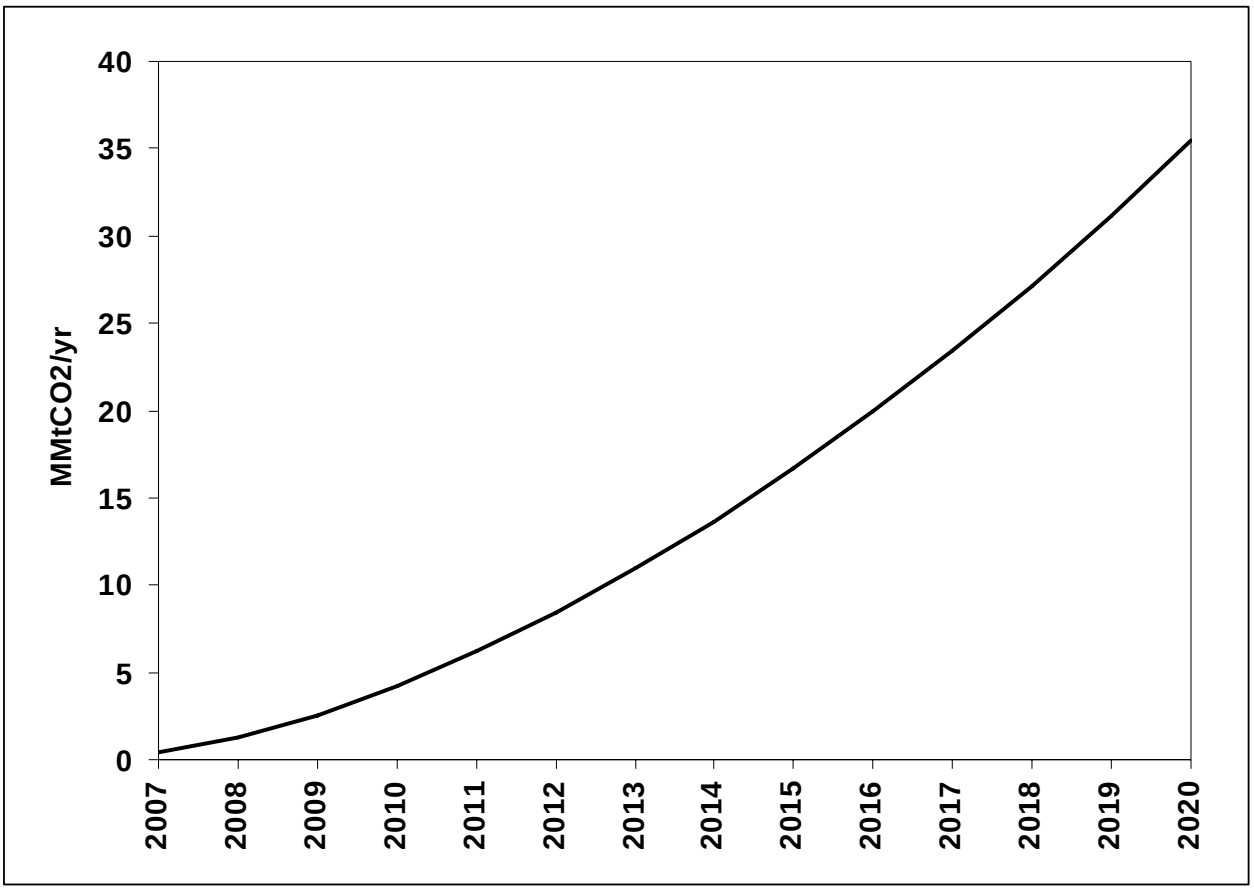


Figure H-2. Cumulative Carbon Savings



The typical cost of conservation easements in North Carolina was used as a basis for the per acre cost of preventing forest conversion. The number of forest acres not converted each year as a result of the program was multiplied by $1,300/acre to get total annual costs each year from 2007–2020. In 2007, annual costs were $1,995,175, rising each year to a total of $19, 951,750 in 2020. Annual discounted costs were estimated using a 5% interest rate. The cumulative cost-effectiveness of the total program was calculated by summing the annual discounted costs and dividing by cumulative carbon sequestration, yielding $3/Mt$CO_2$e.

Key Assumptions: The analysis assumes that 95% of total forest carbon is lost when forests are converted to developed uses and that no appreciable carbon sequestration occurs after development. This is based on expert judgment of the TWG that nearly complete removal of biomass and topsoil occurs when land is developed in North Carolina. The analysis does not account for carbon sequestration in harvested wood products, which may enhance carbon savings if forests falling under this option are managed for harvest. For the purposes of the analysis it was assumed that forests are primarily pine types and coefficients for loblolly-shortleaf stands were used.

The analysis assumes a cost of $1,300/acre, based on data from the NC Forest Legacy Program and the NC Conservation Tax Credit Program. The Forest Legacy Program reports costs of $1,304–1,573/acre for the period 2000 to 2005 for 6,500 acres of land conserved. The North

Carolina Conservation Tax Credit Program reports an average cost to the state in tax credits of $1,318/acre for 1999 to 2005 for 14,500 acres of land conserved. The cost of $1,300/acre, which is at the low end of the range for the NC Forest Legacy Program was chosen with the rationale that product-oriented forest management on some portion of the lands would add value that could not be explicitly factored into the analysis.

Key Uncertainties

- Whether the amount of land in this analysis would be developed during the period covered, in the absence of this option. A map of lands in the North Carolina Conservation Tax Credit Program (http://www.enr.state.nc.us/conservationtaxcredit/images/ctcp2004.gif) shows lands that are at some risk of development (primarily located in the coastal, Triangle and Triad areas of North Carolina).
- The full range of factors that limit current development easement programs. Funding is a primary limiting factor. Program design is also an issue, for example, lack of term easements (35–50 years) and in some cases the inflexible nature of some easement agreements with regard to forest management/harvesting can limit their application.
- The future value of land prices. They could increase to the point of that these programs will not be cost-effective. Easement values will always be less than the total value of the land.

Additional Benefits and Costs

Non-quantified benefits include an improved or maintained quality of life for people near conserved lands as well as wildlife, recreation and watershed improvements.

Feasibility Issues

Better funding of programs to purchase development easements for continued and improved forest management is needed to assure successful implementation of this policy.

Status of Group Approval

Complete.

Level of Group Support

Unanimous.

Barriers to Consensus

None.

AFW-5. Agricultural Biomass Feedstocks for Electricity or Steam Production

Mitigation Option Description

Offset fossil fuel use with agricultural biomass as feedstock for electricity, steam, or heat generation. Agricultural biomass includes, but is not limited to, poultry litter, livestock manure, and crop residues, as well as energy crops (e.g., switchgrass, hybrid poplar). Offsetting fossil fuels use reduces the GHG emissions associated with these fuels.

Note: This option links with AFW-1, which promotes the use of anaerobic digesters and energy utilization. It explores additional opportunities for agricultural biomass energy use. This option also has linkages to Energy Supply Option 1 (ES-1, Renewable Energy Incentives), ES-2 (Environmental Portfolio Standard), and ES-10 (NC Greenpower Renewable Resources Program), and to Residential, Commercial, and Industrial Option 10 (RCI-10, Distributed Renewable and Clean Fossil Fuel Power Generation).

Mitigation Option Design

Goals: Increase agricultural biomass use for electricity, steam, and heat generation to utilize 10% of available biomass by 2010, 25% of available biomass by 2020, and 50% of available biomass by 2030. Voluntary, incentive-based programs should be used to foster development of the industry and associated economic markets.

Timing: See above.

Parties Involved: NCDA&CS, NCSU, NCA&T, Cooperative Extension, NC State Energy Office, North Carolina Division of Air Quality (DAQ), Utilities Commission, electric utilities, livestock and poultry producers, and crop producers.

Other: Explore biomass utilization for electricity, steam, and heat generation using 100% biomass and/or co-firing with other feedstocks (as described in the ES and RCI options cited above).

Implementation Mechanisms

- To build a biomass fuel collection and distribution infrastructure, incentives will be needed in the form of tax breaks (sales and/or income) for incurred capital costs for biomass processing and transportation equipment.
- Inclusion/Expansion of voluntary programs such as NC GreenPower or other energy production-specific cost share programs.
- Increased research to improve return on investment.
- Education for potential producers of power purchase agreements and interconnection with the grid.
- Public education of benefits of electricity produced from biomass, drive demand.

- Additional research for utilization of available biomass for electricity production.
- Additional research for more efficient biomass processing and delivery for utilization in electricity or heat/steam production.

Related Policies/Programs in Place

- NC Renewable Energy Property tax credit. State income tax credit for 35% of construction costs not to exceed $2.5 million or 50% of tax burden.
- Federal Renewable Electricity Production Tax Credit.
- NC GreenPower.

Type(s) of GHG Reductions

CO_2: Savings occur as a result of displacing fossil fuel use in the production of electricity or steam.

Estimated GHG Reductions and Costs (or Cost Savings)

GHG Reduction Potential in 2010, 2020 ($MMtCO_2e$): 0.009, 0.022.

Net Cost per $MtCO_2e$: $54.

Note: The costs and benefits shown above are those associated with in-state biomass feedstock delivery to a power plant or heat/steam end user. The benefit is based on offsetting coal use. The GHG benefits and costs from offsetting fossil-based power or heat/steam generation with biomass generation are covered in the ES and RCI sector. While the costs for purchasing biomass are covered in the ES and RCI sectors, the costs represented here relate to the incentives program needed to develop a biomass collection and distribution infrastructure within the state. Since, the ES-1 and ES-2 analysis captures fuel life cycle benefits, the benefits shown above largely overlap with those quantified under the ES options (most of the biomass generated under this option was to be directed to the electricity sector and only a small amount directed to RCI). Accordingly, the benefits shown above, have been removed from the sector totals adjusted for overlap.

Data Sources: Information on available biomass feedstocks was taken from a recent study supporting a renewable portfolio standard in North Carolina.[43] A primary source of information for this study is a 2004 report from the NC Solar Center.[44] Estimates of available agricultural biomass feedstocks are shown in Table H-9.

[43] *Analysis of a Renewable Portfolio Standard for the State of North Carolina,* prepared by La Capra Associates for the NC Utilities Commission, December 2006.

[44] *Use of Agricultural and Forest Waste as a Distributed Generation Power Resource in North Carolina,* NC Solar Center, July 16, 2004.

Table H-9. Estimated Annual Agricultural Biomass Resources

Feedstock	Annual Resource (dry tons)	Annual Resource (MMBtu)
Corn Stover	963,494	14,259,711
Wheat Straw	60,413	942,443
Poultry Litter[45]	50,000	650,000
Switchgrass	263,132	4,210,112
Hybrid Poplar	302,909	5,149,453
Totals	**1,639,948**	**25,211,719**

NOTE: Dairy and beef cattle and hog manure could be an additional biomass resource for this option, but were left out of this analysis to avoid overlap with AFW-1.

Quantification Methods:

GHG Benefits

Since the direct benefits of using biomass energy in place of fossil fuels at the combustion source (e.g., power plant, industrial boiler) are captured in the applicable ES or RCI analysis, the benefits assessment here focused on the incremental GHG benefits associated with fuel delivery. The analysis assumes that biomass will replace coal.

National average emission factors for coal mining/processing and transport were taken from Argonne National Laboratory's Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation (GREET) Model.[46] The sum of these emission factors is 0.0044 $MtCO_2e$/MMBtu of coal delivered. To estimate the emissions associated with delivering biomass in North Carolina, an emission factor of 0.0009 $MtCO_2e$/MMBtu was developed.[47]

The GHG benefit was estimated as the difference between the emissions from coal delivery and biomass delivery. Emissions for each were based on the amount of fuel to be delivered in each year determined from the goals of the policy (2.5×10^6 MMBtu in 2010 and 6.3×10^6 MMBtu in 2020).

Costs

Implementation of this option notes the need for building biomass collection and distribution infrastructure in the state. To address this need, CCS assumes that a 5-year incentives program

[45] The estimate for poultry litter assumes a broiler population of 100,000,000 in North Carolina and heat content of 6,500 Btu/lb dry solids ("Animal and Poultry Waste-To-Energy", L. Bull, NCSU, at: www.cals.ncsu.edu/waste_mgt/waste%20to%20energy.pdf and litter production of one ton per thousand birds, at www.fibrowattusa.com/US-Press/WattPoultryUSA%20Dec%2001%20on%20Nutrient%20Mgt.pdf. Moisture content of litter is assumed to be 50%. Additional litter produced in turkey or hen/breeder operations not included.

[46] Michael Wang and Ye Wu, Argonne National Laboratory, personal communication with S. Roe, CCS, February 23, 2007.

[47] This emission factor is based on the following data and assumptions: diesel emission factor 10.04 $MtCO_2e$/gal; 23-ton diesel truck fuel consumption, 6 miles/gallon; round trip delivery of 100 miles; biomass has a moisture content of 30%; average heat content of dry biomass is 7,687 Btu/lb.

will be needed. The cost of these incentives was estimated as the difference in the cost of delivered coal versus the cost of delivered biomass from agricultural residues as estimated by the US DOE ($1.27/MMBtu).[48] The 5-year program assumes that sufficient demand will be put in place through the ES and RCI renewables options after 5 years, such that additional incentives for collection and distribution infrastructure are not needed.

Key Assumptions: National average coal emission factors for mining/processing and transport are representative of the coal consumed in North Carolina; the emission factor developed for North Carolina biomass delivery does not include emissions for equipment used for on-site collection/processing of biomass due to a lack of information (the high end of the range of transport radius, 50 miles, was selected to compensate for this lack of data); the cost difference between coal and delivered biomass (national data) are representative for North Carolina and provide a sound basis for the size of the incentives program needed to build collection and transportation infrastructure in the state. All biomass is utilized by the RCI or ES options.

Key Uncertainties

See key assumptions above. Of these assumptions, those associated with the cost and length of the incentives program are the most uncertain. It is also assumed that all of the biomass resource is utilized by the ES or RCI sectors (and the fossil fuel offset benefit remains with those sectors).

Additional Benefits and Costs

- Additional markets for agricultural biomass.
- Economic growth from electricity produced from local feedstocks, rural economy benefits.

Feasibility Issues

- Demand from electric utilities and the RCI sector.

Status of Group Approval

Complete.

Level of Group Support

Unanimous.

Barriers to Consensus

None.

[48] Biomass price differential between agricultural residues and coal from EIA in NEMS biomass supply modeling; $2.50/MMBtu for biomass compared to $1.23 for coal; $2.50/MMBtu represents the price where significant resource potential becomes available; www.eia.deo.gov/oiaf/analysispaper/biomass/table3.html

AFW-6. Policies to Promote Ethanol Production

Mitigation Option Description

Offset fossil fuel use (gasoline) with production and use of starch-based and cellulosic ethanol. Offsetting gasoline use with ethanol can reduce GHGs to the extent that the ethanol is produced with lower GHG content. Provide incentives for the production of ethanol from crops, forest sources, animal waste, and municipal solid waste.

Note: This option is linked to the TLU biofuels option (TLU-7). That option focuses on mechanisms to increase biofuels consumption in North Carolina. The quantification of benefits and costs for each option takes into account the anticipated GHG reductions to be achieved by each.

Mitigation Option Design

Goals: Several projects are being proposed that would result in the production of 150 million gallons of ethanol annually in North Carolina by 2008. Incentives could increase this amount to a volume equivalent to offsetting gasoline consumption in the state by 10% in 2015 and 25% by 2025. These goals are based on cellulosic ethanol being commercially viable by 2015.

Timing: See above.

Parties Involved: NCDA&CS, Department of Administration, Motor Carrier Enforcement Division, DENR, Department of Commerce, NC Rural Center, NCSU, NCA&T, other state agencies, agricultural associations which represent producers of feedstock, petroleum industry trade groups, and various industry and forestry associations.

Other: Identify incentives that encourage the growing of feedstocks, production of ethanol in North Carolina, and the utilization of ethanol all across the state.

- Consider impact of expected increases in transportation costs on delivery of feedstocks to processing facilities, and how this effects optimal distribution of production infrastructure.

Implementation Mechanisms

- Incentives in the form of tax breaks (sales and/or income) for incurred capital costs.
- Streamlined permitting of production facilities. Technical assistance for new producers.
- Active solicitation of new producers.
- Expanded consumer education to drive demand.
- Expanded producer education to develop skilled workforce.
- Expanded research for cellulosic ethanol production, including energy-specific crops. Additional research needed to verify that sufficient cellulosic feedstocks are available to sustainably achieve the long-term (post-2020) production goals of this policy option.

Related Policies/Programs in Place

- NC Renewable Energy Property tax credit. State income tax credit for 35% of construction costs not to exceed $2.5 million or 50% of tax burden.
- Federal Ethanol Mixture Tax Credit, currently $0.50/gallon.

Type(s) of GHG Reductions

CO_2: Life cycle emissions are reduced to the extent that ethanol is produced with lower embedded fossil-based carbon than conventional (fossil) gasoline. Feedstocks used for producing ethanol can be made from crops or other biomass, which contain carbon sequestered during photosynthesis (i.e., biogenic or short-term carbon). There are two different methods for producing ethanol based on two different feedstocks. Starch-based ethanol is derived from corn or other starch/sugar crops. Cellulosic ethanol is made from the cellulose contained in a wide variety of biomass feedstocks, including agricultural residue (e.g., corn stover), forestry waste, purpose-grown crops (e.g., switchgrass), and municipal solid waste. Local production of ethanol also decreases the embedded CO_2e of ethanol compared to importation from the current U.S. primary ethanol producing regions. Current research indicates cellulose-based ethanol production provides up to 72%–85% reduction in GHGs compared to gasoline, whereas an 18%–29% reduction is measured from starch-based ethanol production compared to gasoline.

Estimated GHG Reductions and Costs (or Cost Savings)

GHG Reduction Potential in 2010, 2020 (MMtCO_2e): 0.9, 6.9.

Net Cost per MtCO_2e: $5.

Data Sources: In-state production targets were estimated based on the current and projected levels of gasoline consumption (from the GHG Inventory & Forecast), the policy design parameters, and information on BAU ethanol production.[49] The total BAU production (194 MMgal/year) is based on information gathered from a variety of sources for proposed ethanol plants in North Carolina. The first step in estimating in-state production targets is shown in Table H-10. The estimated in-state production volumes are the volumes needed in each year to show progress toward the 2015 and 2025 policy goals minus the estimated BAU production:

Table H-10. In-State Ethanol Production Needs

Parameter	2010 (MMgal)	2020 (MMgal)
BAU Gasoline Consumption	5,076	5,764
Ethanol Needed for Policy Targets	193	896
BAU Ethanol Production	194	194
Ethanol Production Needed	0	702

Based on 3.8% gasoline offset by 2010 and 17.5% by 2020 (toward 2025 goal of 25%).

[49] BAU production assumes first phase of Agri-Ethanol Plant in operation, 57 MMgal/year in 2007; second phase in 2008, 57 MMgal; E85 Inc. and Clean Burn Fuels also have proposed plants (capacities unknown); assume another 80 MMgal/year BAU production in 2008. Total BAU production is 194 MMgal/year. This value is assumed to remain constant through 2020.

Since the BAU production meets the levels of production needed for 2010, a different ramp up schedule was set up for incentives in the early part of the policy period (2007–2014) to stimulate production using GHG-superior methods (cellulosic ethanol, starch-based ethanol using renewable energy). The overall production schedule is shown in Table H-11.

Table H-11. Assumed ethanol production schedule (MMgal/year)

Assumed Ethanol Production Schedule (MMgal/year)			
2007	–	**2017**	584
2008	10	**2018**	686
2009	60	**2019**	790
2010	110	**2020**	896
2011	160	**2021**	1,026
2012	210	**2022**	1,142
2013	260	**2023**	1,262
2014	310	**2024**	1,384
2015	362	**2025**	1,509
2016	484		

The methods used to estimate GHG reductions and the costs for the policy are provided below.

Quantification Methods:

GHG Reductions

The benefits for this option are dependent on developing in-state production capacity that achieves benefits above the levels of existing and planned (BAU) starch-based production in the United States (the benefits of using ethanol from starch-based production are already accounted for under TLU-7). Emission factors for reformulated gasoline, starch-based ethanol, and cellulosic ethanol were taken from a General Motors/Argonne National Lab study.[50] These emission factors incorporate the GHG emissions during the entire life cycle of fuel production (e.g., for gasoline: extraction, transport, refining, distribution, and consumption; for ethanol: crop production, feedstock transport, processing, distribution, and consumption). These life cycle emission factors are referred to as "well-to-wheels" emission factors (see Table H-12).

Table H-12. Well-to-Wheels Emission Factors

Fuel	Emission Factor (grams CO_2e/mile)
Reformulated gasoline	552
Starch-based ethanol	451
Cellulosic ethanol	154

In addition to cellulosic ethanol production, the other types of ethanol production processes targeted by this option include starch-based processes that achieve similar levels of life cycle

[50] Well-to-Wheels Analysis of Advanced Fuel/Vehicle Systems—A North American Study of Energy Use, Greenhouse Gas Emissions, and Criteria Pollutant Emissions, General Motors, Argonne National Lab, and Air Improvement Resource, Inc., May 2005.

GHG reductions to cellulosic ethanol. These would be starch-based plants that use renewable fuels, such as biomass, biogas, landfill gas, or other renewable fuels. While CCS is not aware of any life cycle emission factors for these types of plants (although several have been proposed in the United States), CCS assumes that reductions similar to cellulosic ethanol can be achieved.

Based on the emission factors shown above, the incremental benefit of the production targeted by this policy over conventional starch-based ethanol is 66% (reduction of CO_2e by offsetting gasoline consumption). This value was used along with the life cycle emission factor for gasoline[51] and the production in each year to estimate GHG reductions.

Costs

Costs for the incentives needed by this policy option are based on the difference in estimated production costs between conventional starch-based ethanol and cellulosic ethanol. The US DOE Energy Information Administration (EIA) estimated that the cost to produce starch-based ethanol is $1.10/gal compared to $1.29/gal, or a difference of $0.19/gal (in $1998).[52] In 2006 dollars, the difference is $0.23/gal. These incentives are considered necessary in the near term (up to 2015) to help commercialize technologies that produce ethanol from cellulose or produce starch-based ethanol using renewable fuels. The incentives should also help to establish the infrastructure to deliver biomass to biorefineries, since producers will seek the local feedstocks or renewable fuels for their operations.

By 2015, it is assumed that advances in cellulosic ethanol production (e.g., enzyme costs, production processes) will make cellulosic ethanol production cost competitive with starch-based production. Hence, the incentives are discontinued beginning in 2015. Note that there is currently federal legislative proposal to offer cellulose an incentive of $0.765/gallon compared to the $0.51/gallon currently offered for ethanol production.[53] If enacted, this $0.255/gallon premium could cover the additional incentives that are assumed to be needed by the State of North Carolina. Obviously, the federal incentives do not assure that production facilities would locate in North Carolina. These federal incentives have not been factored into the cost estimates for this option.

The costs for this option were estimated using the $0.23/gal incentive multiplied by the production needed in each year. By 2015, it is assumed that these incentives will no longer be needed as cellulosic ethanol technologies become fully commercialized. Table H-13 contains the assumed schedule for these incentives.

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[51] In the study mentioned above, the average fuel economy used was 21.3 miles/gallon or 100 miles/4.7 gallons. Multiplying this value by the emission factor of 552 grams/mile yields 11,745 grams/gallon.

[52] DOE EIA analysis can be found at www.eia.doe.gov/oiaf/analysispaper/biomass.html, accessed January 2007.

[53] D. Morris, *Making Cellulosic Ethanol Happen: Good and Not So Good Public Policy*, Institute for Local Self-Reliance, January 2007, at www.newrules.org/agri/cellulosicethanol.pdf, accessed January 2007.

Table H-13. Projected Ethanol Capacity, Incentives Cost, and GHG Benefit: 2007–2020

Year	New Capacity (MMgal)	Incentives Cost (MM 2006$)	GHG Benefit ($MMtCO_2e$)
2007	–	$0.00	0
2008	10	$2.3	0.08
2009	60	$13.8	0.46
2010	110	$25.3	0.85
2011	160	$36.8	1.24
2012	210	$48.3	1.62
2013	260	$59.8	2.01
2014	310	$71.3	2.40
2015	362	$0.0	2.80
2016	484	$0.0	3.74
2017	584	$0.0	4.52
2018	686	$0.0	5.30
2019	790	$0.0	6.11
2020	896	$0.0	6.93

After discounting and leveling the costs from 2007 to 2020, the cost-effectiveness is just under $5/MtCO_2e$.

Key Assumptions: Starch-based ethanol production using renewable fuels achieves equivalent GHG life cycle benefits as cellulosic ethanol; cellulosic production or starch-based production with renewable fuels can achieve the production levels in the near term (2014 production of 310 MMgal/year) required by this policy option; federal tax incentives do not preclude the need for the additional state incentives assumed for the cost estimate.

Key Uncertainties

These include the assumption that commercial-scale cellulosic ethanol production is viable by 2015. Also, that sufficient biomass feedstocks are available in the state to achieve the levels of production proposed in this policy option (see Feasibility Issues below). Finally, that the level of incentives proposed for this option is sufficient to drive the creation of a sustainable biomass ethanol production industry in the state (both in terms of feedstock delivery and production facilities).

Additional Benefits and Costs

- Additional markets for starch/sugar crops and possibly dedicated energy crops.
- Economic growth from locally produced fuels.

Feasibility Issues

- Feedstock supply for corn based ethanol production. It is not clear whether additional production beyond that needed to supply the current and planned facilities can be achieved without negatively affecting food and feed crop production.
- Feedstock supply for cellulosic ethanol production: Assuming that all of the new production would come from cellulosic technology, Table H-14 provides estimates of the amount of biomass feedstock needed in each year. These estimates were derived using biomass conversion factors that range from 70 gallons ethanol/ton biomass through 2011 to 100 gallons/ton by 2020.[54]

Table H-14. Projected Ethanol Capacity and Feedstock Needs: 2007–2025

Year	Ethanol Capacity Needed (MMgal)	Cellulosic Feedstock Needed (tons dry biomass)
2007	–	–
2008	10	142,857
2009	60	857,143
2010	110	1,571,429
2011	160	2,285,714
2012	210	2,333,333
2013	260	2,888,889
2014	310	3,444,444
2015	362	4,020,419
2016	484	5,378,883
2017	584	6,487,503
2018	686	7,619,897
2019	790	8,776,457
2020	896	8,961,825
2021	1,026	10,256,697
2022	1,142	11,422,706
2023	1,262	12,616,196
2024	1,384	13,837,169
2025	1,509	15,085,624

Forestry Options 9&10 yield 0.3 and 2.1 million metric tons (MMt) of biomass in 2010 and 2020, respectively. In addition to these biomass resources, two other studies[55] found that there

[54] Source: John Ashworth, National Renewable Energy Laboratory, personal communication with S. Roe, CCS, April 2007. Values used were 70 gallons/ton thru 2011; 90 gallons/ton 2012–2019; and 100 gallons/ton 2020–2025.

[55] 6.4 million metric tons (MMt) estimated in the following report: National Renewable Energy Laboratory, *A Geographic Perspective on the Current Biomass Resource Availability in the United States*, Technical Report

was a potential for 6.4 to 12.0 MMt of biomass resources in the state (the agricultural biomass resources from AFW-5 are captured in these studies as are purpose-grown energy crops, switchgrass and hybrid poplar, and urban wood waste). Based on these estimates, the resource begins to be fully utilized in the 2018 to 2025 timeframe. More detailed studies of North Carolina biomass resource potential will be needed to verify the availability of feedstocks to achieve the levels of production envisioned by the policy option.

Status of Group Approval

Complete.

Level of Group Support

Unanimous.

Barriers to Consensus

None.

NREL/TP-560-39181, December 2005. 12 MMt estimated in the following report: *Analysis of a Renewable Portfolio Standard for the State of North Carolina*, La Capra Associates, December 2006.

AFW-8. Afforestation and/or Restoration of Non-forested Lands

Mitigation Option Description

Afforest non-forested lands or restore degraded habitats to forests in order to sequester and store carbon above preexisting conditions. Existing afforestation programs are underfunded for the task of this afforestation, typically there is a long wait list for landowner forestation projects. This option covers the provision of additional incentives to increase the rate of afforestation and restoration.

Mitigation Option Design

Goals: Initiate afforestation/restoration projects on 540,000 acres by 2020.

Timing: By Fall 2007 planting season have candidate acreage identified (by county) in cooperation with NRCS, USDA's Farm Service Agency (FSA) and NC Soil and Water Conservation District (SWCD) and NCDFR.[56] By 2010, achieve afforestation projects on 40,000 acres. Achieve a total of 540,000 acres of afforestation projects by 2020.

Parties Involved: Seek to establish a unified cooperative alliance of farm (NC Farm Bureau), forest landowner (NC Woodlands, North Carolina Forestry Association), agencies (NCDFR, NC Dept. of Agriculture), utilities (Duke, Progress Energy), and industrial and non-governmental organizations to promote and implement the coordination needed to reach this historic goal.

Other: Afforestation, the planting of trees on lands that have not recently supported forests, has both carbon sequestration and other environmental benefits—storing over one ton of carbon per acre each year (on-site, not including off-site storage and offsets in products). Afforestation delivers other important benefits such as improved wildlife habitat, reduced soil erosion and fertilizer runoff, and new recreational opportunities. There is a large opportunity for afforestation on agricultural, brownfields, and other lands in North Carolina (possibly greater than 1.5 million acres).[57] These lands are relatively productive for forestry, as the croplands have typically been previously fertilized with mineral nutrients. The average cost-sharing for forestation success in the NC Forest Development Program (FDP) averages between $90 and $200 per acre.[58] The FDP has been the major funding mechanism for state assistance to landowners foresting their lands (~90% of all acres cost shared by currently active NCDFR administered forestation programs[59])

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[56] Natural Resources Conservation Service & Farm Services Agency (USDA), North Carolina Soil and Water Conservation Districts and Division of Forest Resources.

[57] Conservation Compliance: the Clock is Running. Cook, M. and D. Hoag. 1997 SoilFacts, AG-439-23, at http://www.soil.ncsu.edu/publications/Soilfacts/AG-439-23/. Accessed 10/3/2006.

[58] Forest Development Program, Annual Accomplishment Summary, 2006, Joann Hocutt, NC Division of Forest Resources.

[59] Ibid.

and has reached approximately 85% of nonindustrial private forest (NIPF) landowners doing forestation over the last 6 years (1999–2005).[60]

Implementation Mechanisms

An Afforestation Task Force comprised of the Parties Involved would advise NCDFR regarding an enhanced FDP, which will additionally target agricultural lands. The cost share rates would be 100% of establishment costs (only seedlings, planting, and herbicide the first year) plus $200 of rent payments over 5 years which would be expected from a CRP type program. The overall cost to the state per acre of afforestation is about $340. Program and salary costs for three foresters to implement this program would be about $200,000 annually.

Bioenergy markets can increase demand for energy plantations, and potentially influence afforestation/reforestation rates in North Carolina.

Related Policies/Programs in Place

Federal Conservation Reserve Program

Federal Conservation Reserve Enhancement Program

North Carolina Agriculture Cost Sharing Program

North Carolina Forest Development Program

Type(s) of GHG Reductions

- Carbon sequestration from new forest growth.
- Sequestration in durable wood products and fossil fuel offsets from forest based energy (not quantified, outside of analysis period).
- Prevention of emissions from forest conversions and improved retention of soil carbon over agriculture (included in AFW-7).

Estimated GHG Reductions and Costs (or Cost Savings)

GHG Reduction Potential in 2010, 2020 (MMtCO_2e): 0.2, 2.4

Cumulative GHG Reduction Potential (MMtCO_2e, 2007–2010): 15

Net Cost per MtCO_2e: $9

Data Sources: "US Forest Service Methods for Calculating Forest Ecosystem and Harvested Carbon with Standards Estimates for Forest Types of the US," General Technical Report NE-343 (also published as part of the US DOE Voluntary GHG Reporting Program). NC Division of Forest Management, Forest Development Program (Joann Hocutt), cost share rates.

[60] Chris Hopkins' synthesis of Forest Statistics for North Carolina, 2002 and FDP reports.

Quantification Methods: The amount of carbon sequestration achieved over time as a result of afforesting 40,000 acres by 2010 and 500,000 acres from 2010 to 2020 was quantified using carbon sequestration coefficients in Table H-15.

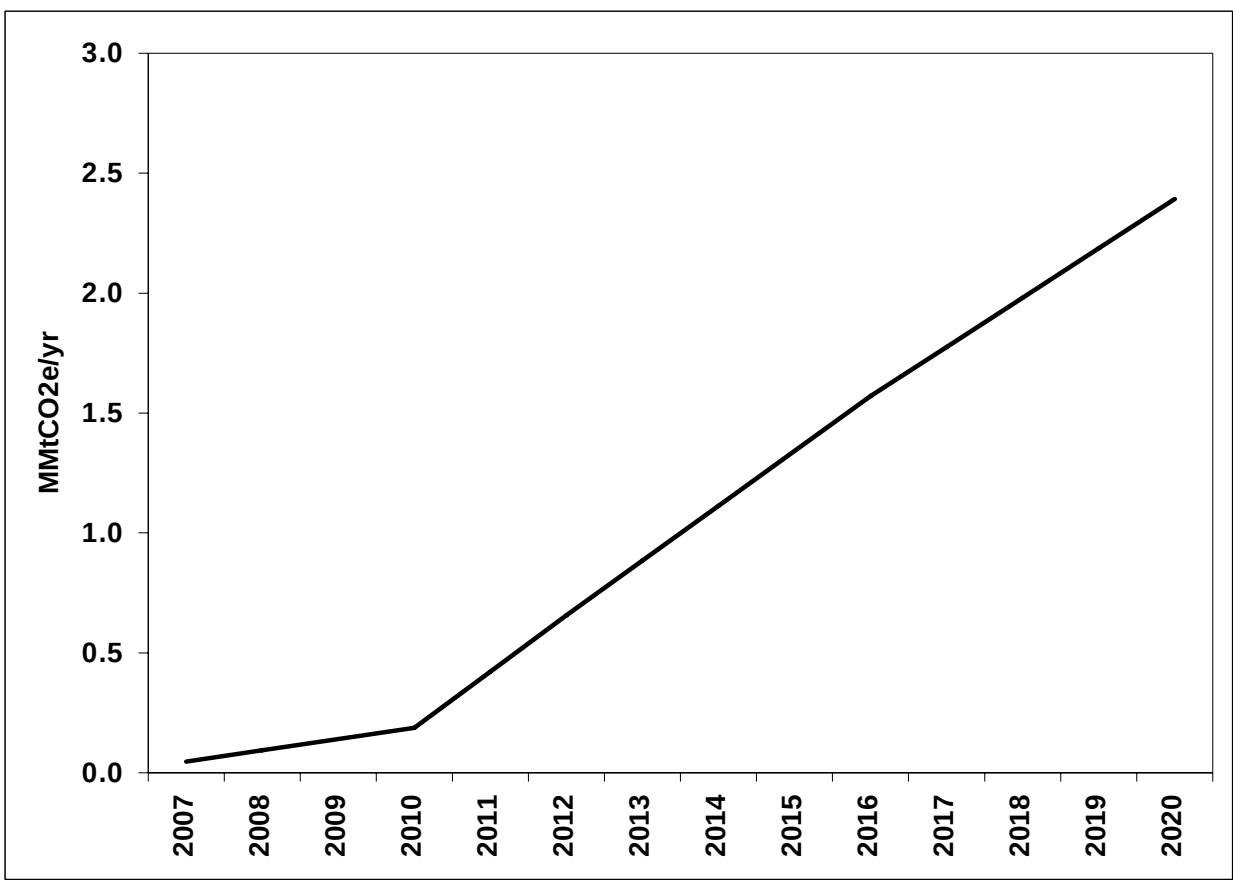
Table H-15. Carbon Sequestration Rates for Loblolly-Shortleaf Pine in the Southeastern United States

Stand Age	MtC/acre/year	MtC/ha/year
0–5	1.28	3.16
5–15	1.12	2.77

Source; USFS GTE NE-343, Table B39

Carbon sequestration was calculated annually, assuming afforestation rates of 10,000 acres/year (4,045 ha/year) from 2007 to 2010 and 50,000 acre/year (20,225 ha/year) from 2011 to 2020. Annual carbon sequestration was calculated separately for stands age 0–5 years and 5–15 years and summed for an annual total. Annual carbon sequestration as a result of afforestation over the time period 2007–2020, under full implementation of the goals outlined above, are shown in Figure H-3. Figure H-4 shows the cumulative total carbon sequestration over the same time period.

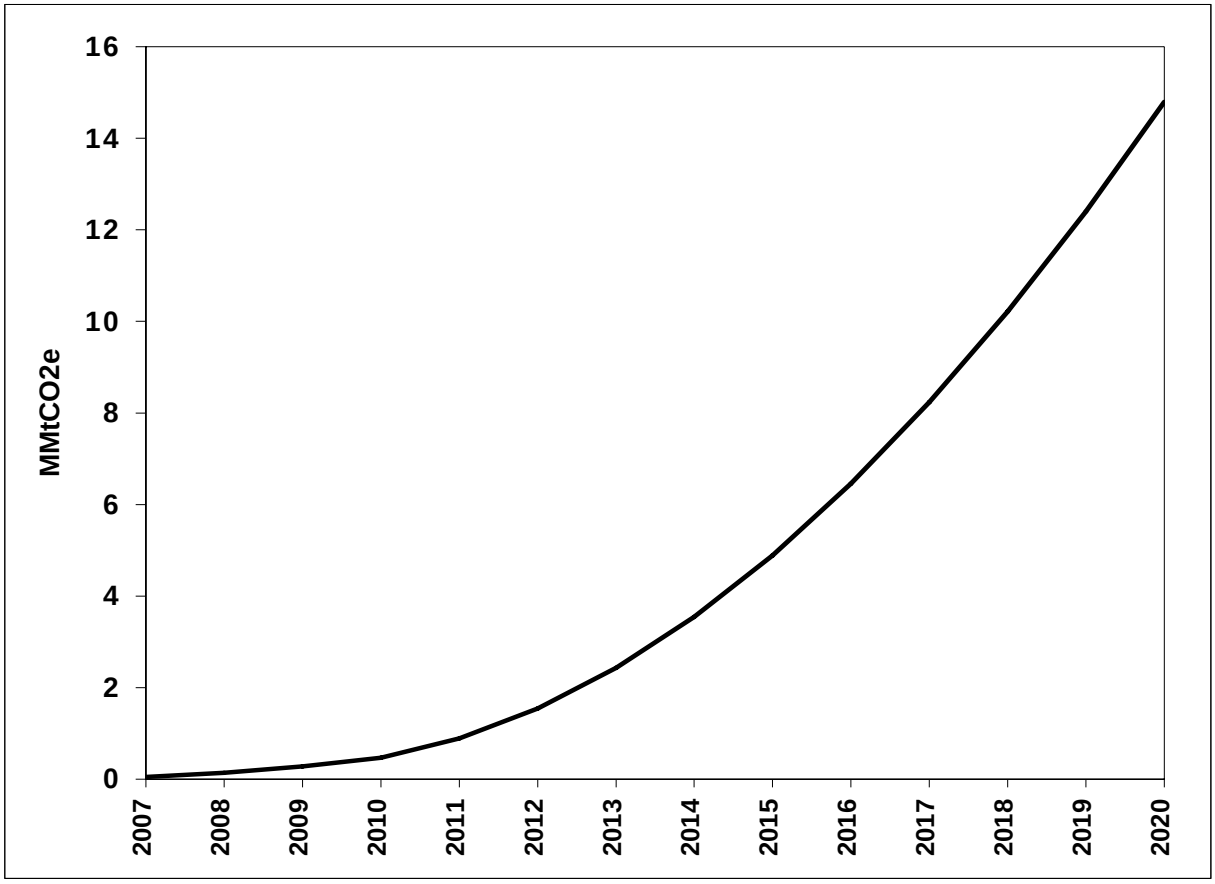
Figure H-3. Annual Carbon Sequestration from Afforestation (MMtCO$_2$)



The cost of afforestation was estimated as an expense of $340/acre (see key assumptions) multiplied by the number of acres planted each year plus $200,000 per year for other program costs (i.e., forestry staff). Afforestation costs from 2007 to 2010 were $3,600,000/year and costs from 2011 to 2020 were $17,200,000/year. Annual discounted costs were estimated using a 5% interest rate. The cumulative costs effectiveness of the total program was calculated by summing the annual discounted costs and dividing by cumulative carbon sequestration, yielding $9/Mt$CO_2$e.

Key Assumptions: All planted forests were assumed to be primarily pine dominant stands. The cost per acre was assumed at $340/acre based on 100% cost share rates for establishment (seedlings, planting, and herbicide the first year) plus $200 of rent payments over 5 years, which would be expected from a CRP type program. An additional program cost covering salary for three foresters to implement this program was assumed at $200,000 annually.

Figure H-4. Cumulative Carbon Sequestration from Afforestation (MMtCO_2)



Key Uncertainties

Whether landowners with un-forested land be willing to accept a new form of land management that may be unfamiliar and has a different investment structure than agriculture.

The rent payments of $40 per acre per year for 5 years is shorter than the duration of CRP program payments which are usually 10 years; we believe this will be sufficient for North Carolina, but this is not certain

Additional Benefits and Costs

Nonquantified benefits include an improved or maintained quality of life for people near conserved lands as well as wildlife and watershed improvements.

Feasibility Issues

Better funding of the FDP to plant forests is feasible given adequate program funding.

Status of Group Approval

Complete.

Level of Group Support

Unanimous.

Barriers to Consensus

None.

AFW-9&10. Expanded Use of Forest Biomass and Better Forest Management

Mitigation Option Description

Through proven and accepted forest management practices, increase forest stand productivity and then direct that productivity into the highest value markets that currently exist. Move the unmarketable logging residue, culls and saplings to the appropriate processing centers for electricity, heating, or liquid fuels. Offsetting fossil fuel use reduces GHG emissions. Increase the growth and yield of production from sustainably managed forest resources through site preparation, competition control, thinning, fertilization, and improved genetics. These practices will increase the amount of carbon stored in forested areas and increase carbon dioxide sequestration rates.

Mitigation Option Design

The goal is the expansion of the production and use of wood products for solid wood products, fiber, and fuel. Such use offsets fossil fuel burning in the production of substitute materials (e.g., cement or steel for solid wood products, and plastic for wood fiber). Wood can substitute for fossil fuels directly in the case of biomass for energy. However, these GHG benefits are not explicitly included in the analysis, which focuses on direct carbon sequestration in forests and in wood products. Having a market for relatively low-value biomass products enables forest management for higher-value solid wood products. (See Additional Benefits and Costs section below for more background.)

Goals: Initiate programs to increase forest productivity by 100% on half of North Carolina timberlands by 2020.

Timing: Begin 2007 and increase to full implementation of management programs on 50% of timberlands by 2020

Parties Involved: NCDFR, NCSU Extension, NC Forestry Association, and NC Woodlands, NCSU CFR.

Other: The goal is to double the productivity of timberland for high value products and claim these products and energy as carbon offsets. We estimate that 1.75% (~57 year rotation) of the state timberland (totaling 17.6 million acres) is cut each year, so most timberland is currently under some sort of management, although much of it is of a very low intensity, indeed 25% of harvested stands continue to be high-graded. Our goal is to improve the management and productivity of these lands, especially on the 11.4 million acres held by non-industrial, private-forest landowners.

Implementation Mechanisms

Enhanced funding of the NC FDP. The full funding level to accomplish program goals would be approximately $230 million annually.[61] This program should include 10% of the budget reserved

[61] Current program funding levels average $2.6 million per year over the last several years.

for forestry extension activities to help educate and motivate forest landowners and professional foresters to better manage their lands and to make the overall program more cost-effective.

Improve markets for low value energy wood through the Renewable Environmental Portfolio Standard legislation.

Recognition and ability to trade carbon credits from both standing forests and harvested wood products.

Related Policies/Programs in Place

NC FDP

Type(s) of GHG Reductions

- Carbon sequestration in forest ecosystems and durable wood products
- Fossil fuel offsets from forest based energy (GHG benefits accounted for elsewhere, i.e., in AFW-6 and in RCI and ES sectors)
- Prevention of emissions from forest conversions and improved retention of soil carbon (not quantified)

Estimated GHG Reductions and Costs (or Cost Savings)

GHG Reduction Potential in 2010, 2020 (MMtCO_2e): 1.5, 5.9.

Cumulative GHG Reduction Potential (MMtCO_2e, 2007-2010): 48.

Net Cost per MtCO_2e: –$13

Data Sources: "US Forest Service Methods for Calculating Forest Ecosystem and Harvested Carbon with Standards Estimates for Forest Types of the US," General Technical Report NE-343 (also published as part of the US DOE Voluntary GHG Reporting Program). USFS Forest Inventory Program. Annual Survey of Manufactures (2005). NC Division of Forest Management, Forest Development Program (Joann Hocutt), Forest Statistics for North Carolina, 2002.

Quantification Methods: There are two parts to this analysis. The first quantifies the impact of the program on forest carbon (i.e., carbon in living and dead biomass and in soils within the forest ecosystem) and the second quantifies the impact on carbon removed from the forest as durable wood products. The starting point for both parts of the analysis is the same. The Forest Inventory Analysis (FIA) database from the USFS was queried to determine forest productivity (cubic feet of harvested volume) and area of timberlands in North Carolina for the most current year available (2002). Productivity and area data were classified into two categories, pine-dominant forest types and all other forest types (most of which contain oak species) (Table H-16).

Table H-16. Baseline Forest Productivity in North Carolina (FIA, 2002)

Forest Type	Area (acres)	Productivity (cubic feet)	Productivity per area (cubic ft/acre)
Pine (all pine dominant types)	4,960,656	8,483,024,291	1,710
Oak (all other types)	12,716,225	21,841,789,468	1,718

Forest ecosystem carbon sequestration was estimated using average annual carbon sequestration coefficients in Table H-17. Coefficients for pine-dominant stands were based on carbon sequestration rates in Loblolly-shortleaf pine stands in the southeastern United States and coefficients for all other forests were based on carbon sequestration in oak-hickory forests in the southeastern United States (USFS GTR NE-343). Separate coefficients were available for average and high productivity Loblolly-shortleaf pine stands. Coefficients for improved productivity oak-hickory stands were not available and thus were estimated by assuming increased rates of carbon sequestration equivalent to 50% of the increases reported for the high productivity Loblolly-shortleaf pine stands.

Table H-17. Forest Ecosystem Carbon Sequestration Coefficients for North Carolina

	Pine (average productivity)	Pine (high productivity)	Oak (average productivity)	Oak (high productivity)*
Stand age	Carbon Stocks (MtC/acre)			
0	40.16	44.41	26.84	27.46
90	90.00	96.56	89.84	91.92
Average annual carbon sequestration (MtC/acre/year)	0.55	0.58	0.70	0.71

* USFS does not provide high-productivity carbon values for oak forest types in the Southeast. These values were calculated by assuming a 2.3% increase in carbon sequestration, which is half the percent increase reported by the USFS for pine.

Source: USFS GTR NE-343, Tables A39, A40, A44

Baseline annual carbon sequestration was calculated by applying the average productivity coefficients in Table H-17 to the forest areas in Table H-16 each year from 2009 to 2020. To calculate carbon sequestration under program implementation, the forest areas achieving high and average productivity each year were modeled for the time period of 2009–2020. Under program implementation, forest treatments to improve productivity were assumed to begin in 2007. By 2009, high levels of productivity would be realized on 10% of the targeted area split equally between pine and oak classes (total targeted area is 50% of all North Carolina timberland, or 8,838,441 acres). Each year, the area of forests at high productivity levels was increased by 10% until the full goal level was achieved in 2018. Total forest area was held constant each year.

High productivity and average productivity carbon sequestration coefficients were applied to the relevant forest area estimates each year to calculate forest carbon sequestration under program implementation. Baseline levels were subtracted to calculate the incremental increase in carbon sequestration as a result of the program. The results are shown in Table H-18.

Table H-18. Summary of Forest Area and Forest Carbon Sequestration from 2009 to 2020 (under baseline and program implementation)

Year	High productivity forests (acre)	Average productivity forests (acre)	Carbon sequestration under the program (MMtC/year)	Baseline carbon sequestration MMtC/year)	Carbon sequestration above baseline (MMtC/year)
2009	883,844	16,793,037	11.66	11.65	0.02
2010	1,767,688	15,909,193	11.68	11.65	0.03
2011	2,651,532	15,025,349	11.70	11.65	0.05
2012	3,535,376	14,141,505	11.71	11.65	0.07
2013	4,419,220	13,257,661	11.73	11.65	0.08
2014	5,303,064	12,373,817	11.75	11.65	0.10
2015	6,186,908	11,489,973	11.76	11.65	0.12
2016	7,070,752	10,606,129	11.78	11.65	0.13
2017	7,954,597	9,722,285	11.80	11.65	0.15
2018	8,838,441	8,838,441	11.81	11.65	0.17
2019	8,838,441	8,838,441	11.81	11.65	0.17
2020	8,838,441	8,838,441	11.81	11.65	0.17

Forest sequestration in harvested wood products (HWP) was calculated following guidelines published by the USFS. Details on each step of the analysis can be found in the guidelines, following the methodology referred to as “Land-based estimation.” In general, forest productivity is used as a starting point and regional patterns in the disposition of carbon through various HWP pools are used to model carbon stock changes in HWP over time. The methodology calculates the transfer of carbon through four pools over time: wood in use (i.e., building materials, furniture), wood in landfills (i.e., products that were previously in use and have been discarded), wood burned for energy capture, and wood that has decayed or burned without energy capture. The difference in the amount of carbon entering the “in use” and “landfill” pools at the beginning of a year and the amount remaining one year later equals total net annual carbon flux in HWP.

For this analysis, carbon sequestration in HWP was compared under baseline and program implementation levels. Baseline levels of carbon sequestration in HWP were calculated using forest productivity values in Table H-16 and default coefficients for pine and oak forest types and for the southeast region. Two modifications were made to estimate carbon sequestration under program implementation. First, productivity levels were gradually increased as described above for the analysis of forest ecosystem carbon. Second, the disposition pattern was modified such that 10% less wood was disposed in landfills and instead shifted to use for energy production, thus providing more feedstocks for bioenergy. In both cases, the annual area harvested in North Carolina was assumed to be 317,800 acres (Forest Statistics for North Carolina, 2002).

The results of the analysis are summarized in Table H-19, which show the amount of carbon stored in landfills and products in-use each year above what would have happened in the

baseline, spanning the period 2009–2020. While the amount of additional carbon in landfills and in products from a given harvest decreases each year (as it is emitted through decay or energy capture), additional wood is harvested each year and at increasing levels of productivity. Thus for every year in the time series, the carbon stocks in the wood products pool are increasing. This analysis is carried out until 2020 and does not capture the continued disposition of carbon through the wood products pools in time.

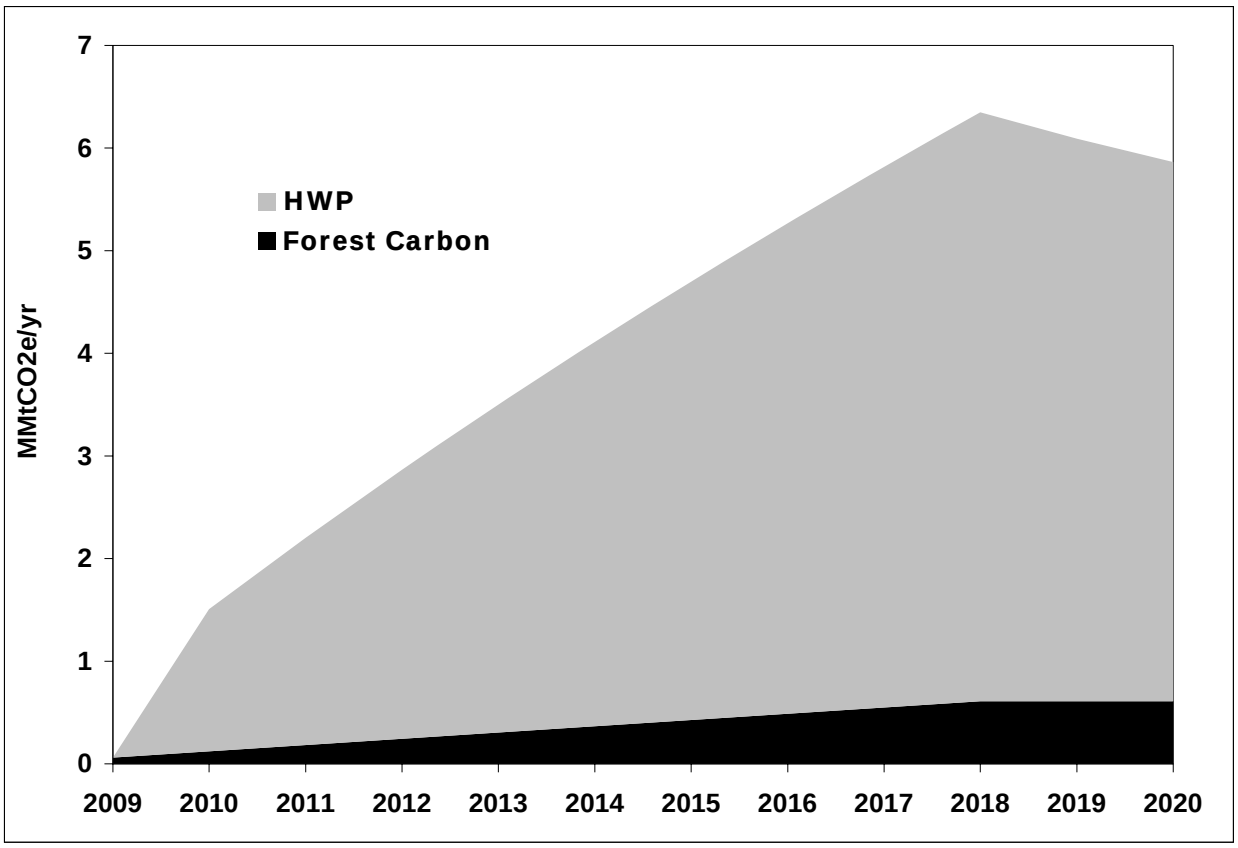
An alternative approach for estimating carbon stored in wood products is to estimate the amount of carbon remaining in products and landfills after 100 years and apply that value to the year of harvest (GTR NE-343, 1605b technical guidelines). This approach accounts for emissions that would occur over 100 years following harvest in the year of the harvest, and assumes that the carbon remaining after 100 years is stored permanently. This approach was developed to simplify annual reporting of carbon stored in wood products and to account for the long term dynamics of carbon flows in harvested wood products pools. For comparison to the analysis covering 2009–2020, the amount of carbon above baseline levels that would be stored in products and landfills 100 years after harvest is shown in the last column of Table H-19. The total carbon still stored in HPW from harvests that occurred during 2009–2020, after 100 years is 5.15 MMtC (compared to the cumulative carbon stored in HWP during 2009–2020, of 11.93 MMtC).

Table H-19. Disposition of Carbon Stored in Landfills and in Products over Time (amount is additional carbon above baseline levels)

Year of harvest	Carbon from the harvest in year x (x=row) that is in use or landfill by the end of year y (y=column) (MMtC)												
	2009	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**100 years later**
2009	0.19	0.18	0.17	0.16	0.16	0.15	0.14	0.14	0.13	0.13	0.12	0.12	0.07
2010		0.39	0.37	0.35	0.33	0.31	0.30	0.29	0.28	0.27	0.26	0.25	0.14
2011			0.58	0.55	0.52	0.49	0.47	0.45	0.43	0.42	0.40	0.38	0.21
2012				0.78	0.73	0.69	0.66	0.63	0.60	0.57	0.55	0.53	0.27
2013					0.97	0.92	0.87	0.82	0.78	0.75	0.72	0.69	0.34
2014						1.17	1.10	1.04	0.99	0.94	0.90	0.86	0.41
2015							1.36	1.28	1.21	1.15	1.10	1.05	0.48
2016								1.56	1.46	1.38	1.31	1.25	0.55
2017									1.75	1.65	1.56	1.48	0.62
2018										1.95	1.83	1.73	0.69
2019											1.95	1.83	0.69
2020												1.95	0.69
Carbon stored in HWP in year (MMtC)	0.19	0.57	1.12	1.84	2.71	3.73	4.90	6.20	7.64	9.20	10.69	12.13	5.15
Annual Carbon Sequestration (MMtC/year)	0.00	0.38	0.55	0.71	0.87	1.02	1.17	1.30	1.44	1.56	1.49	1.43	

Figure H-5 shows the combined estimated GHG reductions from forest carbon and HWP.

Figure H-5. Annual Carbon Sequestration From Increased Productivity



There are also emissions reductions associated with the displacement of fossil fuels by bioenergy generated from the additional biomass feedstocks resulting from forest productivity enhancements. Under this option, an estimated 15 MMt more biomass would be used for bioenergy from harvests during 2009–2020.

The cost of management treatments to increase productivity was estimated at $8.80/acre/year multiplied by the number of acres treated each year (see Table H-18 for annual area of high productivity forests). Revenue from the additional harvested wood products generated from productivity treatments was also taken into consideration. The value of additional wood products harvested during 2028–2037 as a result of productivity treatments during 2009–2020 was calculated assuming a future value of $390/acre (a present value $119/acre). If productivity is doubled on a total of 8,842,200 acres of forestland during 2009–2020, this gives a net present value (NPV) of $1.05 billion in wood products. The combined NPV of the above costs and cost savings were summed for a total NPV of –$639 million (cost savings). Annual discounted costs and cost savings were estimated using a 5% interest rate. The total NPV was divided by cumulative carbon sequestration, yielding a cumulative cost-effectiveness of –$13/Mt$CO_2$e.

Key Assumptions: Productivity increases were assumed to be distributed equally between pine and oak forest types; cost of productivity treatments were assumed at $8.80 per acre per year over 30 years, based on NC Forest Development Program cost-share rates for a one site preparation and planting, three fertilization treatments, and one pre-commercial timber stand improvement. The added value of revenue generated from increased forest productivity was

estimated at $390 per acre. The analysis assumes no change in total forest area over the period of analysis.

Key Uncertainties

The silviculture of doubling forest growth is relatively well understood. The key questions involved are centered on feasibility of addressing all targeted land. Will 50% of forest landowners be willing to intensify their forest management with the full range of stand improvement and fertilization foreseen by this program? This may require new forms and levels of public outreach not previously practiced by forestry institutions.

Success of this mitigation option is heavily dependent on the expansion of markets for forest products including lumber and bio-fuels. Future housing markets are not predictable and it remains to be seen the degree to which wood-based renewable energy will be adopted. Use of wood for electricity production will be dependent on regulation and/or incentives. Technologies for cellulosic ethanol are still under development for commercial scale production. And, the future for all renewables is largely dependent of future fossil fuel prices.

Additional Benefits and Costs

Increased benefits from forest management would increase forestland owner incomes and the probability of retaining land in forest cover.

Additional study is needed and potential controls put in place to assure that biomass combustion to displace fossil fuel combustion does not produce higher air pollutant emissions than the fossil fuel replaced (e.g., criteria and toxic air pollutants). It should also be noted that biomass combustion does not provide a “free ride” that automatically reduces the CO_2 in the atmosphere. The atmosphere can not discern one CO_2 molecule from another, so until the downward slope on CO_2 concentrations in the atmosphere have been stabilized at an acceptable equilibrium point or concentration, the emissions of CO_2 from biofuels and other renewable sources will not effectively be operating on a “closed loop” basis and be legitimately ignored as part of the problem as well as of the solution.

Feasibility Issues

NCDFR personnel have indicated they can substantially increase implementation of the FDP with landowners, given increased funding, but a many-fold increase in this program will require a large and unknown administrative and on-the-ground personnel demand. The FDP may not be funded at levels high enough to fully support this program. Other complementary mechanisms of support may be necessary.

A standard application of fertilizer on otherwise unmanaged land can increase average productivity about 66% for hardwood and 77% for softwoods. Note that the fertilizer applications are envisioned to be organic fertilizers from agricultural by-products or sewage treatment and not commercial fertilizers (which have significant embedded GHGs). Improved genetics continues to add 5 to 10% in productivity for each improved generation. Improved thinning and competition control can increase high value product growth by 20%. The logging residue that currently is left in the woods is about 15% of total productivity and this too would be increased by fertilization and could be used for biomass energy. While not all improvements are

directly multiplicative, it is clear that we can double forest productivity and more than double carbon sequestration by forests in North Carolina. If goal levels were extended into the future, productivity could be doubled on all managed timberlands by 2030.

Additional study is needed to establish sustainability criteria for different forest types, so that minimum standards are in place to address the amount of biomass to be left on the ground to achieve desired benefits for forest health, soil, water quality, and wildlife habitat.

Status of Group Approval

Complete.

Level of Group Support

Unanimous.

Barriers to Consensus

None.

AFW-11. Landfill Methane and Biogas Energy Programs

Mitigation Option Description

Provide incentives that will result in an increase in the recovery of landfill methane for use as an energy source. Increasing the recovery of landfill methane will reduce emissions of this GHG and will offset the use of fossil fuels for commercial/industrial heat/steam generation or electricity production.

Note: This option has linkages to ES-1 (Renewable Energy Incentives), ES-2 (Environmental Portfolio Standard), and ES-10 (NC GreenPower Renewable Resources Program), and to RCI-10 (Distributed Renewable and Clean Fossil Fuel Power Generation).

Mitigation Option Design

Out of approximately 130 open and closed landfills in the state, only about 15 sites are currently recovering landfill methane for energy use.

Goals: Increase the number of uncontrolled municipal solid waste landfills recovering methane as an energy source, such that 50% of the landfill gas being generated is controlled by 2020. This can be done through development of additional landfill gas to energy (LFGTE) projects. For sites where LFGTE is not feasible, implement flaring controls to achieve the goal.

Timing: By 2010, implement LFGTE at 10 sites not currently using these technologies; by 2020, achieve full implementation of the policy (50% coverage of generated LFG).

Parties Involved: Municipal and county governments, private solid waste management companies, local economic development agencies, NC DENR, NC Department of Commerce, NC Utilities Commission, non-government organizations, and public interest groups.

Other: No distinction is made between the direct use of landfill methane (e.g., for heat or steam) and the use of methane for electricity generation.

Implementation Mechanisms

- Undertake a geographic information system (GIS)-based assessment of landfill gas to energy project potentials focusing on identifying end-users (may have been undertaken by NC Solar Center and State Energy Office). Work with the NC Department of Commerce to use the findings for economic development purposes.
- Establish and expand tax credits for the development of landfill gas to energy projects.
- Develop policies that encourage state agencies to enter into fuel/power purchasing agreements that will result in increased landfill gas to energy projects.
- Research the potential to alleviate burdens associated with the NC Utilities Commission rules regarding the treatment of landfill gas to energy projects as regulated utilities.

- Develop a grant program or other incentives to encourage the installation of gas collection systems at landfills for the purpose of flaring landfill methane.

Related Policies/Programs in Place

- NC State Energy Office, NC DENR, NC Solar Center, US EPA, Landfill Methane Outreach Program.
- US DOE, Renewable Energy Production Incentive; U.S. Internal Revenue Code, Section 45; 15 NCAC 13B Section .1500, Standards for Special Tax Treatment of Recycling, and Resource Recovery Equipment and Facilities.

Type(s) of GHG Reductions

Methane Destruction: Flaring or production of energy from landfill gas results in the destruction of methane.

GHGs Reduced via Fossil Fuel Reductions: Use of landfill gas for generating heat/steam or electricity can offset fossil fuel use (e.g., natural gas, coal), which will reduce emissions of CO_2, CH_4, and N_2O from the combustion of fossil fuels.

Estimated GHG Reductions and Costs (or Cost Savings)

GHG potential in 2010, 2020 ($MMtCO_2e$): 1.1, 2.9.

Net Cost per $MtCO_2e$: $1.

Information available from the RCI TWG indicates that Option RCI-10 will consume some landfill gas as part of the renewable energy portfolio. The benefit associated with this consumption of an equivalent amount of natural gas (to be claimed under the RCI option) is 0.002 $MMtCO_2e$ in 2010 and 0.007 $MMtCO_2e$ in 2020. These values were subtracted out as overlap in the Summary List of Mitigation Option Recommendations (p. 1).

Data Sources: The NC GHG Inventory & Forecast was used as the source of data on available methane emissions. Cost information from US EPA's Landfill Gas Cost Model (LFGcost), version 1.4 was used to estimate costs.[62]

Quantification Methods:

GHG Savings

GHG savings were estimated by determining the CO_2 equivalent for the available methane to be reduced in 2010 (20%) and 2020 (50%) at uncontrolled landfills in the state.[63]

[62] Four different runs of LFG cost were provided by A. Singleton, ERG, to S. Roe CCS, March 2007, based on the scenarios specified in the quantification methods section of this option.

[63] The 20% value in 2010 is assumed based on the goal of implementing projects at 10 of about 100 uncontrolled sites. These first sites are likely to be implemented at the largest (highest producing) sites. Based on emissions modeling conducted by CCS during the development of the Inventory & Forecast, implementing projects at 10 of the largest uncontrolled sites would cover at least 20% of the waste in place at these sites and the potential methane emissions.

Additional GHG reductions are achieved by offsetting fossil fuel that would have been used to create the thermal energy or electricity generated by these landfill gas projects. These reductions are provided as part of the LFG cost output and were added to the reductions associated with methane collection and destruction.

Costs

Costs were estimated by applying US EPA's LFGcost Model (version 1.4) to three different scenarios. The parameters for these scenarios are shown below. These three scenarios were designed to capture the range of costs likely to be seen in North Carolina to apply LFG capture and utilization projects to both uncontrolled and flared landfills. Data to support these three scenarios are shown in Table H-20.

Table H-20. Three Landfill Gas Control Options Modeled

Scenario	**1**	**2**	**3**
Current Controls	None	None	Collection & Flare
Year Landfill Opened	1988	1988	1983
Year Landfill Closed	2010	2010	2017
Annual Waste Acceptance Rate (tons)	38,000	38,000	88,000
Landfill Size (acres)	100	100	200
Technology Employed	Small Engine/ Generator Set	Direct Use (heat or steam)	Engine/ Generator Set
LFG cost Value of Energy Produced	$0.045/kWh	$4.50/MMBtu	$0.045/kWh
Modeled Costs	$2.72	-$0.82	$0.15

The data in Table H-20 show that the direct use option results in a net savings (project revenues greater than costs), while the small and standard engine/generator set options result in net costs. Direct use is typically only cost-effective when the landfill is within a short radius to the end user (usually a half mile or less). Hence, the opportunities for direct use are limited. Standard engine/generator set projects (800 kW and greater) are used at projects with moderate to large methane production (48 million cubic feet/year collected on average). Small engine/generator set projects are applicable at smaller sites.

To develop an overall cost for this policy option, CCS used the following assumptions on the mix of projects that would be implemented to achieve the policy's goals: 17% of methane reduced via standard engine/generator set projects (17% of the US EPA Landfill Methane Outreach Program database waste in place is at flared sites, which could be candidates for these projects); 20% of methane is controlled by direct use projects (number of projects assumed to be limited by location of end users); and the remaining 63% is assumed to be controlled by small engine/generator set projects.

Using this blend of LFG energy projects and the LFG cost output data, a blended cost-effectiveness estimate of $1.57/Mt$CO_2$e was estimated. This cost-effectiveness estimate was applied to the emission reductions to be achieved in each year by the policy to estimate costs in each year.

CCS did not include the effects of the Section 45 Tax Credit for production of renewable energy, since this credit may or may not be available to many of the projects that would be installed due to this policy. Inclusion of this tax credit would have a small effect at lowering the costs for the policy. For example, the cost-effectiveness for the small engine/generator set option would decrease from the $2.72/Mt estimate shown above to $2.46/Mt.

Information available from the RCI TWG indicates that Option RCI-10 will consume some landfill gas as part of the renewable energy portfolio. The latest estimates are 40 billion Btu's of LFG in 2010 and 138 billion Btu's in 2020. The benefit associated with the offset of an equivalent amount of natural gas (to be claimed under the RCI option) is 0.002 $MMtCO_2e$ in 2010 and 0.007 $MMtCO_2e$ in 2020. These were subtracted at the bottom of the Summary List of Mitigation Option Recommendations (p. 1) to account for this overlap.

Key Assumptions: For this analysis, available methane means 75% of the methane emitted at uncontrolled landfills, which is the assumed amount that can be captured for energy use. Available methane also includes methane being flared at sites with collection and flaring. In 2010, projects are implemented to capture 20% of the available methane; in 2020 this rises to 50%. For costs, the key assumptions are the value of energy produced: $0.045/kWh for electricity projects and $4.50/MMBtu for direct use projects. Higher values for these energy products could reduce the costs of this option significantly.

Key Uncertainties

See Key Assumptions in the section above.

Additional Benefits and Costs

Additional benefits include reducing landfill gas emissions of volatile organic compounds, including some that are hazardous air pollutants.

Feasibility Issues

The practice of locating landfills in very rural areas often results in a lack of viable local end users. Furthermore, the possible treatment as a regulated utility can also prevent landfill gas to energy projects from being developed.

Status of Group Approval

Complete.

Level of Group Support

Unanimous.

Barriers to Consensus

None.

AFW-12. Increased Recycling Infrastructure and Collection

Mitigation Option Description

Increase the quantity of materials recovered for recycling with specific attention given to materials with the greatest ability to reduce energy consumption during the manufacturing process and to materials that may be used as a fuel source (e.g., clean wood waste). Reducing the quantity of materials being put in landfills reduces future landfill methane emissions potential, while recycling reduces emissions associated with the manufacturing of products from raw materials.

Mitigation Option Design

Goals: Increase per capita recovery in the state 25% by 2020.

Timing: Achieve a 10% increase in per capita recovery by 2010 and a 25% increase in per capita recovery by 2020.

Parties Involved: Municipal and county government, private solid waste and recycling management companies, commercial, industrial and institutional generators, and NC DENR.

Other: For the purpose of calculating per capita recovery, yard waste (yard trash as defined in G.S. 130A-290) and other vegetative debris are not included. Yard waste is banned from disposal in municipal solid waste (MSW) and construction and demolition (C&D) landfills and experiences large annual fluctuations in both generation and recovery.

Implementation Mechanisms

Numerous options exist for increasing recovery in the state. These options should be thoroughly researched to determine the effectiveness of the various options.

Expand statewide waste reduction education campaigns to include the GHG mitigation benefits of increased waste reduction.

Research the feasibility and impacts of implementing statewide disposal bans for corrugated cardboard and clean wood waste. Make recommendations based on findings.

Conduct extensive research into increased pre-consumer and post consumer food waste diversion[64] covering at a minimum: infrastructure needs, barriers to increasing infrastructure,

[64] Pre-consumer food waste is the easiest to compost. It is simply the preparatory food refuse and diminished quality bulk, raw material food that is never seen by the consumer. This food waste is generally already separated from the rest of the waste stream generated, thus no change is needed to keep contaminants out of the future compost. Post-consumer food waste is more challenging because of separation issues. It is simply the table scrap food refuse. Often, after the consumer is done with the food, the waste is subject to contaminants and a decision has to be made on how to separate the food from other waste. This can be done by having an extra trash can that is only used for food waste.

incremental cost of food waste diversion and potential climate change benefits of food waste diversion. Make recommendations based on findings.

Provide technical assistance to local governments on operating more effective recycling programs (ongoing).

Lead by example for state agencies.

Legislative actions:

- Require any new host community agreements between a landfill developer and any local government to include provisions for a minimum prescribed level of recycling services within a maximum allowable service area per recycling drop site.
- In lieu of, or in addition to existing local per capita waste reduction goals; requires local government 10-year solid waste management plans to include an enforceable per capita recovery goal that increases annually until 2020. Enforceability may be achieved by requiring local governments to take specific actions to improve performance if goals are not met. An initial minimum recovery rate would have to be determined.
- Increase funding to the NC Solid Waste Management Trust fund for increased grants to local governments and to private sector for additional infrastructure expansion.

Related Policies/Programs in Place

State Solid Waste Management Trust Fund, NC Division of Pollution Prevention and Environmental Assistance (DPPEA) – Community Waste Reduction and Recycling Grants, Recycling Business Development Grants; Local Government Assistance Team, NC DPPEA; Recycling Business Assistance Center, NC DPPEA.

GS 130A-309.10(f) and (f1) – Materials Banned from Disposal and Incineration.

GS 130A-309.09A – Local Government Solid Waste Responsibilities.

Type(s) of GHG Reductions

Landfill Methane: Reducing the quantity of organic material entering the anaerobic environments found in landfills will result in a decrease in methane gas releases from landfills.

Upstream Energy Use Reductions: Less energy is generally required to manufacture goods from recycled feedstocks than from virgin feedstocks. For example, the addition of recycled glass cullet to the glass making process allows manufacturers to operate furnaces at lower temperatures.

Estimated GHG Reductions and Costs (or Cost Savings)

GHG potential in 2010, 2020 (MMtCO_2e): 0.20, 0.49.

Net Cost per MtCO_2e: $13.

EPA's Waste Reduction Model (WARM)[65] was used to estimate the emissions associated with the State's current level of recycling and with the goal of increasing recycling by 25% per capita. WARM is based on a life cycle approach, which reflects emissions and avoided emissions upstream and downstream from the point of use. As such, the emission factors provided in WARM provide an account of the net benefit of recycling and source reduction actions to the environment.

Data Sources: WARM input data for both the baseline and policy scenarios were provided by the NC DPPEA.[66] WARM is provided by the EPA and can be accessed along with documentation at the Web site: http://www.epa.gov/climatechange//wycd/waste/calculators/Warm_home.html.

Quantification Methods: Two different runs of the WARM model were conducted. The first was done to represent the current levels of recycling in the state and the associated GHG emissions and reductions. The second was done to represent emissions and reductions associated with increasing the current level of recycling by 25% per capita. Table H-21 summarizes the results of both model runs:

Table H-21. Analysis Results Using WARM

WARM Run	Total GHG Emissions ($MtCO_2e$)
Baseline (without existing recycling)	6,379,586
Baseline (with recycling)	4,439,516
25% Recycling Increase Above Baseline	3,952,224
GHG Reductions	**487,292**

The 2020 reductions is determined as the difference in emissions estimated for the baseline (with existing recycling programs) and the emissions estimated for the 25% increase in recycling run. For 2010, the reduction was estimated using a factor of 0.4 multiplied by the 2020 benefit (10/25, since a 10% per capita recovery is the policy goal for 2010).

Table H-22 provides the WARM output for the 25% increase in per capita waste recycling. The following waste types are small quantities in North Carolina and were excluded from modeling in WARM: motor oil, oil filters, antifreeze, lead-acid batteries, textiles, and mixed C&D recovery. Since these waste types were left out, recycling for all of the other commodities was

[65] Version 7, August 2005. From http://www.epa.gov/climatechange//wycd/waste/calculators/Warm_home.html. EPA created the Waste Reduction Model (WARM) to help solid waste planners and organizations track and voluntarily report greenhouse gas emissions reductions from several different waste management practices. WARM is available both as a Web-based calculator and as a Microsoft Excel spreadsheet. WARM calculates and totals GHG emissions of baseline and alternative waste management practices—source reduction, recycling, combustion, composting, and landfilling. The model calculates emissions in metric tons of carbon equivalent (MtCE), metric tons of carbon dioxide equivalent ($MtCO_2E$), and energy units (million Btu) across a wide range of material types commonly found in municipal solid waste. For explanation of methodology, see the EPA report: *Solid Waste Management and Greenhouse Gases: A Life-Cycle Assessment of Emissions and Sinks* (EPA530-R-02-006), at http://epa.gov/climatechange/wycd/waste/SWMGHGreport.html.

[66] Jim Hickman, NC Division of Pollution Prevention and Environmental Assistance and NC AFW TWG, personal communication and WARM spreadsheets provided to S. Roe, CCS, January 2007.

increased by just over 26% to mimic a 25% increase in per capita recovery. All commodities were increased by the same percentage. In reality, one would expect to see a differential increase that would likely result in more fiber recovery by percentage increase. No distinction was made between C&D waste and MSW. All of the waste was lumped together as mixed MSW. Yard waste was also left out of the modeling. It is banned from disposal in C&D and MSW landfills in North Carolina (it can be mulched, composted or sent to land clearing and inert debris (LCID) landfills (a.k.a. stump dumps).

Table H-22. WARM Output for the 25% Increase in Recycling Run

Material	Incremental Recycling (Tons)	Incremental GHG Emissions from Recycling ($MtCO_2E$)	Incremental Landfilling (Tons)	Incremental GHG Emissions from Landfilling ($MtCO_2E$)	Total Incremental GHG Emissions ($MtCO_2E$)
Aluminum Cans	1,464	(21,855)	(1,464)	(56)	(21,912)
Steel Cans	1,981	(3,548)	(1,981)	(76)	(3,624)
Copper Wire	0	0	0	0	0
Glass	11,573	(3,238)	(11,573)	(445)	(3,683)
HDPE	1,871	(2,628)	(1,871)	(72)	(2,700)
LDPE	0	0	0	0	0
PET	2,927	(4,548)	(2,927)	(112)	(4,660)
Corrugated Cardboard	28,994	(79,455)	(28,994)	(17,019)	(96,474)
Magazines/third-class mail	819	(2,214)	(819)	185	(2,029)
Newspaper	38,794	(135,448)	(38,794)	31,095	(104,353)
Office Paper	694	(1,722)	(694)	(1,573)	(3,295)
Phonebooks	0	0	0	0	0
Textbooks	0	0	0	0	0
Dimensional Lumber	7,770	(19,058)	(7,770)	3,038	(16,020)
Medium Density Fiberboard	0	0	0	0	0
Food Scraps	NA	NA	0	0	0
Yard Trimmings	NA	NA	0	0	0
Grass	NA	NA	0	0	0
Leaves	NA	NA	0	0	0
Branches	NA	NA	0	0	0
Mixed Paper, Broad	476	(1,508)	(476)	(250)	(1,757)
Mixed Paper, Resid.	10,049	(31,857)	(10,049)	(4,237)	(36,094)
Mixed Paper, Office	0	0	0	0	0
Mixed Metals	25,383	(184,436)	(25,383)	(975)	(185,411)

Material	Incremental Recycling (Tons)	Incremental GHG Emissions from Recycling ($MtCO_2E$)	Incremental Landfilling (Tons)	Incremental GHG Emissions from Landfilling ($MtCO_2E$)	Total Incremental GHG Emissions ($MtCO_2E$)
Mixed Plastics	21	(31)	(21)	(1)	(32)
Mixed Recyclables	1,437	(4,122)	(1,437)	(401)	(4,523)
Mixed Organics	NA	NA	0	0	0
Mixed MSW	NA	NA	0	0	0
Carpet	0	0	0	0	0
Personal Computers	289	(712)	(289)	(11)	(723)
Clay Bricks	NA	NA	0	0	0
Aggregate	0	0	0	0	0
Fly Ash	0	0	0	0	0
Total	134,539	(496,379)	(134,539)	9,088	(487,291)

Columns associated with source reduction, waste combustion, and composting were removed from this WARM output table, since these management practices were not considered in the modeling.

Costs

The following information on typical landfill tipping fees, current households served by curbside recycling, households not served by curbside recycling, and the costs for adding curbside recycling services and public education was provided by the NC Office of Pollution Prevention & Environmental Assistance:[67]

- Tons of municipal solid waste diverted by 25% per capita increase: about 134,000;
- Average Landfill tipping fee: $35 ton (conservative estimate, as communities served by transfer stations could pay up to $40/ton);
- Households currently served by curbside recycling: 1,384,653;
- Households not receiving curbside service in towns w/ populations of 5,000 or more: 516,941 (community size is assumed to be the minimum for cost-effective recycling services);
- Estimated cost of enhancing education and/or adding more materials to what is already collected in areas receiving curbside recycling: $0.60 per household per year; and
- Estimated cost (based on state averages) for adding curbside collection: $27 per household per year.

The cost for enhancing existing programs is 1,384,653 households × $0.60 = $830,792/year.

[67] Jim Hickman, NC Office of Pollution Prevention & Environmental Assistance, personal communication with S. Roe, CCS, January 2007.

The cost of adding programs is 516,941 households × $27.00 = $13,957,407/year, for a total cost of $14,788,199/year.

The avoided costs of disposal are 134,000 households × $35.00 = –$4,690,000/year, resulting in a net cost of $10,098,199/year.

From the annual cost above and the estimated GHG reductions estimated with WARM, a discounted and levelized cost-effectiveness of $1/Mt$CO_2$e was estimated.

Key Assumptions: Within WARM, the following modeling options were selected: (1) material that is source reduced comes from current mix of recycled/virgin materials, not 100% virgin material; (2) North Carolina landfills recover landfill gas at the national average of recovery; (3) landfill gas that is recovered is used for energy recovery, not flared; (4) landfill gas collection system efficiency is 75%; and (5) default distances for materials delivery to management facility were used (20 miles).

Key Uncertainties

See “Key Assumptions” in the previous section.

Additional Benefits and Costs

Reduction in other air and water pollutant emissions associated with product manufacturing and transport.

Feasibility Issues

Some legislative action would be required (see Implementation Mechanisms section). Some infrastructure development might be required.

Status of Group Approval

Complete.

Level of Group Support

Unanimous.

Barriers to Consensus

None.

AFW–13. Urban Forestry Measures

Mitigation Option Description

Urban forest cover protection and management offers a potentially cost-effective mechanism to reduce energy use, to store/sequester carbon and mitigate land use change (conversion of forest and agricultural lands to residential sites). Strategic planting of trees to shade houses and air conditioning units can yield energy savings of 15% to 50% on cooling costs.[68] Planting of shade trees can reduce summer cooling costs, with only marginal increases in winter heating costs, particularly in mild climates. In addition, depending on local conditions, tree planting can reduce wind-speed and further reduce energy costs. The net direct impacts of tree planting are generally estimated to be positive, taking these factors into account.

Mitigation Option Design

Goals: Increase urban tree cover by planting three additional trees (i.e., three more than planned) on all new construction sites starting in 2008, and by planting three new trees on 25% of existing housing units in 2007 by 2020, with the aim of achieving a 25% reduction in annual heating and cooling costs.

Timing: see above.

Parties Involved: Local government planning agencies, developers, residential and commercial property owners, North Carolina Urban Forest Council, DENR, NCDFR, electricity providers, NC Cooperative Extension Service.

Other: Research on cost savings from urban tree planting indicates that planting three additional trees around a housing unit yields cost savings on the order of $150/year for the southeast (EPA Cooling our Communities). Annual residential energy expenditures on heating and cooling are estimated at $585/year per housing unit in North Carolina (NC State Energy Plan 2003). Therefore, planting three additional trees amounts to about a 26% reduction in household cooling costs.

Implementation Mechanisms

Across all implementation mechanisms, recognize the potential for urban tree programs to minimize solar energy resources. Provide technical assistance for proper tree orientation that minimizes shading of areas that could be used for solar energy collection, where solar energy is a consideration.

- Use incentives to encourage developers to retain trees and green space on new construction sites. (Incentives could include density credits, priority during approval/permitting process, utility credits, etc.). Require developers to retain a **minimum** of 10% canopy cover and those that retain more than that receive increased credits and permitting priority.

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68 Cooling Our Cities, U.S. Environmental Protection Agency PM-221.

- Promote the creation of proper tree preservation and protection ordinances in communities across the state.
- Provide recognition to communities that increase their canopy cover percent (e.g., with CO_2 credits). Allow municipalities and or homeowners to direct benefits of CO_2 sequestration via trees to their budget or charity of their choice, respectively.
- Install green roofs on state buildings—green roofs reduce urban heat islands by providing shade and the cooling effects of evapotranspiration, absorb air pollution, collect airborne particulates, and store carbon, and insulate a building from extreme temperatures (reducing energy costs).
- Support the use of consulting arborists by developers/contractors in the planning and review process prior to building permit submission.
- Empower the NCDFR to increase seedling availability to Urban Tree planting on public lands. Expand the interaction with community groups and environmental organizations.
- Enhance existing programs, e.g., Neighborwoods, through the Alliance for Community Trees (ACT) to educate and cost-share on encouraging seedlings for urban or residential plantings on private home ownerships.
- Increase level of support/education to municipalities in order to ensure proper maintenance and care of increased urban forest.
- Designate an Urban Forestry Extension specialist to NCSU Forestry Extension staff.

Related Policies/Programs in Place

North Carolina Urban Forest Council

America the Beautiful Program

The Urban and Community Forestry Grant Program

Trees Across Raleigh

Trees Across Asheboro

Quality Forward

Type(s) of GHG Reductions

- Increased carbon sequestration in urban trees
- Avoided emissions by reduced energy use in heating and cooling
- Improved retention of soil carbon (not quantified)
- Carbon sequestration in the form of durable wood products and fossil fuel offsets from forest based energy (not quantified)

Estimated GHG Savings and Costs per $MtCO_2e$

GHG Reduction Potential in 2010, 2020 ($MMtCO_2e$): 1.4, 4.3.

Net Cost per $MtCO_2e$: –$11.

Data Sources: Cooling Our Cities, US EPA PM-221; "Shade trees reduce building energy use and CO_2 emissions from power plants," H. Akbari, Environmental Pollution, 116:S119–S126, March 2002; "U.S. Forest Service Effects of Urban Forests and their Management on Human Health and Environmental Quality" (http://www.fs.fed.us/ne/syracuse/Data/data.htm); U.S. Census Bureau statistics on housing units in North Carolina.

Quantification Methods: GHG reductions were quantified separately for (1) carbon sequestration in trees and (2) decreases in residential energy consumption. Trends in U.S. Census Bureau data on housing stocks in North Carolina from 1939 to 2005 were used to model the North Carolina housing stock from 2007 to 2020. Since 1938, there was positive growth in housing stock nearly all years, with growth rates ranging from 0.8%/year during 1980–1989 to 11%/year during 1995–1998. However, growth in housing stock decreased after 1998 and, on average, was –6.5%/year during 2000–2005. Growth in annual housing stock from 2007 to 2020 was calculated by assuming 72,454 new housing units were constructed in 2006 (based on the average number constructed per year from 2000 to 2005) and a –6.5%/year growth rate for 2007–2020.

Under the first goal, three additional trees beyond what would normally be planted around new construction in North Carolina are planted on 100% of new housing units every year from 2007 to 2020. Carbon sequestration in urban trees was assumed at 6 kg C/tree/year, which is the average for North Carolina in the USFS assessment of urban forest resources (Nowak et al., 2001). Total annual carbon sequestration was calculated each year, including sequestration in trees planted that year and trees planted prior to that year under the program. The results are shown in Table H-23.

Table H-23. Carbon Sequestration in Trees Planted on New Housing Units, 2007–2020

Year	New Housing Units	Number of trees planted	C sequestered in new trees (kg C)	C sequestered in trees planted since 2007 (kg C)	Total CO_2e sequestered ($MMtCO_2e$)
2007	67,751	203,253	1,219,515		0.004
2008	63,353	190,059	1,140,356	1,219,515	0.009
2009	59,241	177,723	1,066,335	2,359,872	0.013
2010	55,395	166,186	997,118	3,426,207	0.016
2011	51,800	155,399	932,395	4,423,326	0.020
2012	48,437	145,312	871,872	5,355,721	0.023
2013	45,293	135,880	815,278	6,227,594	0.026
2014	42,353	127,060	762,358	7,042,872	0.029
2015	39,604	118,812	712,873	7,805,231	0.031
2016	37,033	111,100	666,600	8,518,105	0.034
2017	34,630	103,889	623,331	9,184,705	0.036

Year	New Housing Units	Number of trees planted	C sequestered in new trees (kg C)	C sequestered in trees planted since 2007 (kg C)	Total CO_2e sequestered ($MMtCO_2e$)
2018	32,382	97,145	582,870	9,808,036	0.038
2019	30,280	90,839	545,035	10,390,906	0.040
2020	28,314	84,943	509,657	10,935,942	0.042

Under the second goal, three additional trees are planted on 25% of the 2007 housing stock over the course of 2007–2020. North Carolina housing stock in 2007 was estimated at 4,080,759 units based on U.S. Census Bureau data. The analysis assumed gradual implementation such that three trees were planted on 72,871 units each year. By 2020, three additional trees were planted on a total of 1,020,190 units (25% of 2007 housing stock). Total annual carbon sequestration in these trees was calculated each year, including sequestration in trees planted that year and trees planted prior to that year under the program. The results are shown in Table H-24.

Table H-24. Carbon Sequestration in Trees Planted on Existing Housing Units, 2007–2020

Year	# Units Planted	Number of trees planted	C sequestered in new trees (kg C)	C sequestered in trees planted since 2007 (kg C)	Total CO_2e sequestered ($MMtCO_2e$)
2007	72,871	218,612	1,311,672		0.005
2008	72,871	218,612	1,311,672	1,311,672	0.010
2009	72,871	218,612	1,311,672	2,623,345	0.014
2010	72,871	218,612	1,311,672	3,935,017	0.019
2011	72,871	218,612	1,311,672	5,246,690	0.024
2012	72,871	218,612	1,311,672	6,558,362	0.029
2013	72,871	218,612	1,311,672	7,870,035	0.034
2014	72,871	218,612	1,311,672	9,181,707	0.038
2015	72,871	218,612	1,311,672	10,493,380	0.043
2016	72,871	218,612	1,311,672	11,805,052	0.048
2017	72,871	218,612	1,311,672	13,116,725	0.053
2018	72,871	218,612	1,311,672	14,428,397	0.058
2019	72,871	218,612	1,311,672	15,740,070	0.063
2020	72,871	218,612	1,311,672	17,051,742	0.067

GHG reductions from avoided use of fossil fuels for heating and cooling were also estimated. Reductions in energy consumption were based on energy cost savings from tree planting. Research on cost savings from urban tree planting indicates that planting three additional trees around a housing unit yields cost savings on the order of $150/year/household for the southeast (EPA Cooling our Communities). Annual residential energy expenditures on heating and cooling are estimated at $584.60/year per housing unit in North Carolina (NC State Energy Plan 2003). Therefore, planting three additional trees amounts to about a 26% reduction in household heating

and cooling costs. It was assumed that at 26% reduction in costs translated into a 26% reduction in annual electricity and natural gas consumption for residential heating and cooling.

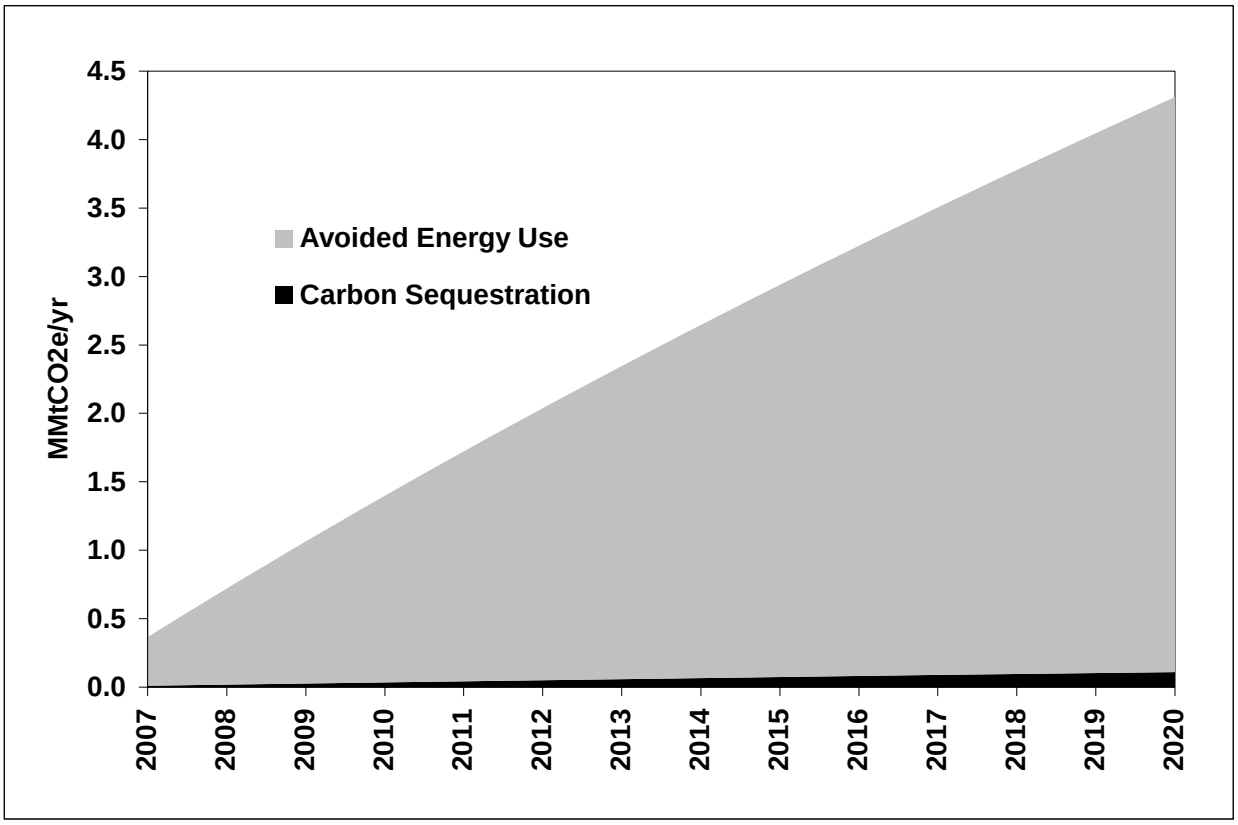
In North Carolina, about 52.9 and 26.7 million Btu's (MMBtu's) of electricity and natural gas, respectively, are used for heating and cooling per household (NC State Energy Plan 2003). It was assumed that housing units that planted trees under the program reduced electricity and natural gas consumption by 13.75 and 6.94 MMBtu's per year, respectively. Electricity and natural gas emission factors (0.1578 and 0.0528 tonnes CO_2e/MMBtu, respectively) were calculated from the NC Inventory and Forecast (the electricity emission factor was modified based on additional data from the electricity sector in North Carolina, as documented in the ES Methods Memo). The resulting GHG emission reductions are shown in Table H-25.

Table H-25. GHG Reductions From Reduced Use of Fossil Fuels for Household Heating and Cooling

Year	Housing units with additional trees	Energy Reductions-electricity (MMBtu)	Energy Reductions - natural gas (MMBtu)	CO_2e reductions-electricity (MMtCO_2e)	CO_2e reductions-natural gas (MMtCO_2e)	Total Reductions (MMtCO_2e)
2007	140,622	1,934,109	976,195	0.31	0.05	0.36
2008	276,845	3,807,732	1,921,861	0.60	0.10	0.70
2009	408,957	5,624,794	2,838,979	0.89	0.15	1.04
2010	537,223	7,388,967	3,729,403	1.17	0.20	1.36
2011	661,894	9,103,684	4,594,865	1.44	0.24	1.68
2012	783,202	10,772,155	5,436,986	1.70	0.29	1.99
2013	901,366	12,397,382	6,257,280	1.96	0.33	2.29
2014	1,016,590	13,982,172	7,057,164	2.21	0.37	2.58
2015	1,129,064	15,529,150	7,837,964	2.45	0.41	2.86
2016	1,238,968	17,040,771	8,600,918	2.69	0.45	3.14
2017	1,346,469	18,519,328	9,347,185	2.92	0.49	3.42
2018	1,451,721	19,966,970	10,077,847	3.15	0.53	3.68
2019	1,554,871	21,385,701	10,793,917	3.38	0.57	3.95
2020	1,656,056	22,777,399	11,496,343	3.59	0.61	4.20

The relative contribution of tree carbon sequestration and reductions in energy consumption to overall GHG reductions is shown in Figure H-6. Reductions in avoided use of fossil fuels for heating and cooling makes up most of the reductions over the time series.

Figure H-6. GHG Reductions from Urban Forestry Programs



Urban tree planting has both costs and cost savings. The cost of planting and maintaining urban trees was estimated by multiplying the number of trees planted each year by $250/tree. The cost is based on a reported range of $10–$500 per tree (Akbari 2002). The range reflects variation in program implementation and consideration of full life cycle costs (i.e., pruning/maintenance, liability, waste disposal). The value of $250/tree is near the midpoint of this range. (The reported range does not consider potential uses of biomass waste for energy purposes, neither does this analysis.) In addition, cost savings was estimated by multiplying the cumulative number of households in the program each year by $150/year/household. Net annuals costs (costs minus cost savings) are initially positive. However, starting in 2011, as more households see cost savings from reduced heating and cooling requirements, costs become increasingly negative. Annual discounted costs were estimated using a 5% interest rate. The cumulative costs effectiveness of the total program was calculated by summing the annual discounted costs and dividing by cumulative carbon sequestration, yielding –$11/t$CO_2$e.

Key Assumptions: Future growth of housing stocks is assumed at 6.5%/year, starting with 4,080,759 existing units in 2007. Three additional trees per household will reduce heating and cooling costs by $150/year. Costs of planting and maintaining urban trees is $250/tree. Average tree carbon sequestration in urban trees is 6 kg C/tree/year.

Key Uncertainties

The cost-effectiveness of urban tree planting for carbon sequestration is not in doubt. The impact of hurricanes on shade trees is important, but uncertain in timing and spatial distribution. The biggest question is the administration of this program to reduce the cost of planted trees. The ability to implement these programs in smaller and newer communities[69] may be limited by administrative capacity in these communities.

Additional Benefits and Costs

Additional benefits include an improved or maintained quality of life for people in improved urban forests as well as wildlife, recreation and watershed improvements.

Feasibility Issues

Urban forestry is in general a known field with appreciable positive impacts. As noted in the Implementation Mechanisms section, tree shading programs have the potential to minimize solar energy collection potential. Programs need to recognize this issue and allow for siting of solar energy collectors, wherever solar energy is likely to be used.

Status of Group Approval

Complete.

Level of Group Support

Unanimous.

Barriers to Consensus

None.

[69] Predominantly in former agricultural lands without trees, although many new communities on former forest land completely clear all original trees.

Appendix I
Cross-Cutting Issues
Mitigation Option Recommendations

Summary List of Mitigation Option Recommendations

Option No.	Mitigation Option Name	GHG Reductions ($MMtCO_2e$)			Net Present Value 2007–2020 (Million $)	Cost-Effective-ness ($/$tCO_2e$)	Level of Support
		2010	2020	Total 2007–2020			
CC-1	GHG Inventories and Forecasts	*Not quantified*					UC
CC-2	State Greenhouse Gas Reporting	*Not quantified*					UC
CC-3	State Greenhouse Gas Registry	*Not quantified*					UC
CC-4	State Climate Public Education and Outreach	*Not quantified*					UC
CC-5	State Climate Change Adaptation Strategy	*Not quantified*					UC
CC-6	Options for Goals or Targets (for CAPAG in support of LCGCC)	*Not quantified*					UC

GHG = greenhouse gas; $MMtCO_2e$ = million metric tons of carbon dioxide equivalent; $/$tCO_2e$ = dollars per metric ton of carbon dioxide equivalent; UC = unanimous consent (all agree); CAPAG = Climate Action Plan Advisory Group; LCGCC = [North Carolina} Legislative Commission on Global Climate Change.

CC-1. GHG Inventories and Forecasts

Mitigation Option Description

Greenhouse gas (GHG) emissions inventories and forecasts are essential to understanding the magnitude of all emission sources and sinks (both anthropogenic and natural), the relative contribution of various types of emission sources and sinks to total emissions, and the factors that affect trends over time. The initial use for inventories and forecasts will be to inform state leaders and the public on statewide trends, opportunities for mitigating emissions or enhancing sinks, and verifying GHG reductions associated with implementation of North Carolina's Climate Action Plan. However, it is expected that other uses of the data will be identified as the program evolves. The responsibility for preparing GHG inventories and sinks should reside with the Division of Air Quality (DAQ), which has the expertise needed to systematically compile information on GHG sources and sinks using established methods and data sources. Other state agencies as well as private facilities (sources) will need to provide data to DAQ on a periodic basis. This program should be integrated with existing DAQ inventory and forecast functions as seamlessly as possible. The DAQ, in the September 2005 report under the Clean Smokestacks Act. Committed to an annual completion of a mandatory GHG inventory of point source facilities holding a Title V permit for calendar year 2008. The inventory and forecast will utilize this and other information in an on-going effort to be improved and expanded over time, based on improvements to the accuracy and completeness of data needed to support this effort, usefulness of the data, and experiences gained on these large point sources. The Division has expressed a desire to expand this inventory to a full scale effort as resources, expertise and priorities allow.

Mitigation Option Design

Goals:

- Develop a periodic, consistent, and complete inventory of emission sources and sinks on a continuing basis with forecasts to reasonable and realistic future years (5 and 10 years), to and including 2020 (and eventually beyond).
- Inventory of all natural and man-made emissions generated within the boundaries of the state (i.e., production-based inventory approach) as well as emissions associated with energy imported and consumed in the state (i.e., consumption-based inventory approach).
- Provide a projection of the emissions from the same source categories and on the same basis into the future to produce a realistic forecast of what the emissions will be in future years reflecting expected growth and application of scheduled and implemented mitigation options.
- Provide a basis for documenting reductions and credits "by difference" from year to year.

Timing: The program should be implemented as soon as possible as allowed by funding. Reporting by major (Title V) point sources holding an air permit will begin for calendar year 2008. The process for these and other sources should repeat as often as necessary to track significant reductions or increases, beginning with every year for major point sources and every

third year for other sources to be in agreement with routine EPA air emissions reporting requirements and regulations for other regulated air pollutants.

Parties Involved: All emission sources and sinks (both anthropogenic and natural) should be included.

Other:

- The state has already initiated efforts for collecting 2008 emissions data for point sources subject to a North Carolina Title V air permit.
- The *GHG Inventories and Forecasts Design Characteristics Matrix* provided in Annex A is reference material to, not explicitly part of, this mitigation option.

Implementation Mechanisms

North Carolina currently requires major point sources of criteria air pollutants to report their emissions to the state, and DAQ reviews the emissions for accuracy annually. An unofficial "difference" report should be issued annually for major point sources and include updates as available for other categories that are on an every-third-year rotation. The state would develop inventories and forecasts for area sources, small point sources and mobile emissions. Individual facilities could optionally secure outside certification for any emissions they wish to register for potential sale/credit.

Related Policies/Programs in Place

The DAQ already has a computer system for other air pollutants from these source categories. The major (Title V) facilities already report annually, and the GHG are now in the computer system pollutant tables.

Type(s) of GHG Reductions

Establishing a GHG inventory and forecasting function within state government assists in the tracking, management, and ultimately reduction of GHG emissions. It does not reduce GHG emissions per se. Public disclosure of GHG emissions may encourage sources to reduce emissions.

Estimated GHG Reductions and Costs (or Cost Savings)

This option could be considered an administrative and enabling function of the Climate Action Plan (including enabling any future cap-and-trade options) and will incur overhead costs but not directly reduce emissions per se except where these data motivate reductions for public relations by individual companies or sources.

Data Sources: Many.

Quantification Methods: Several—will be designed to follow standard, comparative and accepted approaches that allow exchange/sale of emission credits should this become a need in this state.

Key Assumptions: No new significant DAQ resource needs are expected in order to implement this option, at least as it applies to large stationary sources.

Key Uncertainties

- Adequacy of ongoing funding for a statewide GHG inventory and forecasting function.

Additional Benefits and Costs

None cited.

Feasibility Issues

None cited.

Status of Group Approval

Complete.

Level of Group Support

Unanimous consent.

Barriers to Consensus

None.

CC-2. State Greenhouse Gas Reporting

Mitigation Option Description

GHG reporting reflects the measurement and reporting of GHG emissions at a statewide, sector, or sub-sector level to support tracking and management of emissions. GHG reporting can help sources identify emission reduction opportunities and reduce risks associated with possible future GHG mandates by moving up the learning curve. Tracking and reporting of GHG emissions would also help in the construction of periodic state GHG inventories. GHG reporting is typically a precursor for sources to participate in GHG reduction programs, opportunities for recognition, a GHG emission reduction registry, and to secure "baseline protection." Further, collaboration with other states in the development of a GHG reporting program could enable North Carolina to influence the development of GHG reporting practices throughout the region and nation and build consistency and reciprocity with other state or regional GHG reporting programs.

Mitigation Option Design

Goals:

- Subject to consistently rigorous quantification, GHG reporting should not be constrained to particular sectors, sources, or approaches, in order to encourage GHG mitigation activities from all quarters.
- GHG reporting should be phased in by sectors as standardized quantification protocols, base data, and tools become available, and as responsible parties become clear. All entities (including the state, municipalities, and other jurisdictions) should be allowed to report GHG emissions associated with their own activities and any programs they may implement to reduce GHG emissions.
- GHG reporting should be applicable on a voluntary basis to all sources (e.g., combustion, processes, vehicles, etc.) but applied with common sense regarding de minimis emissions. GHG reporting may be required by DAQ for some categories of sources through normal state rulemaking procedures.
- The goal should be reporting of GHG emissions on an organization-wide basis within North Carolina, but with greatest possible detail by facility in order to facilitate baseline protection.
- Reporting should occur annually on a calendar-year basis for all six traditional GHGs and other pollutants for which the Intergovernmental Panel on Climate Change (IPCC) develops global warming potentials (GWPs) (e.g., black carbon and ozone).
- GHG emissions reports should be verified through self-certification and NC DENR spot-checks. To qualify for future registry purposes, reports should undergo third-party verification.
- Every effort should be made to maximize consistency with federal, regional, and other states' GHG reporting programs and quantification protocols.

- Reporting of direct emissions[1] should be required; reporting of emissions associated with purchased power and heat[2] should be phased in; and reporting of other indirect emissions[3] should be allowed.
- Reporting of emissions from GHG reduction projects should qualify for reporting, when they are identified as such, and adhere to equally rigorous quantification standards.
- The reporting program should provide for appropriate public transparency of reported emissions.

Timing: A GHG reporting program should be implemented as soon as possible.

Parties Involved: All entities that can verify ownership of GHG emissions.

Other: The *GHG Reporting Design Characteristics Matrix* provided in Annex A is reference material to, not explicitly part of, this mitigation option.

Implementation Mechanisms

North Carolina currently requires major point sources of criteria air pollutants to report their emissions to the state, and DAQ reviews the emissions for accuracy annually. An unofficial "difference" report should be issued annually for major point sources and include updates as available for other categories that are on an every-third-year rotation. The state would develop inventories and forecasts for area sources, small point sources and mobile emissions. Individual facilities could optionally secure outside certification for emissions reports that they may wish to register in a GHG registry.

Related Policies/Programs in Place

- Approximately 2,400 point source facilities/sources in North Carolina report criteria pollutant emissions (about 350 Title V's report annually) in order to comply with various federal and state regulatory programs. Most electric generating units are also required to report carbon dioxide (CO_2) emissions to the United States Environmental Protection Agency (US EPA) and the Energy Information Administration (EIA). Some sources may report GHG emissions on a voluntary basis to federal, state, or privately run programs. Otherwise, there is currently no broad, statewide GHG reporting program in North Carolina.
- The DAQ will be collecting GHG emissions from stationary sources subject to a North Carolina state Title V (about 350 facilities) air permit beginning in calendar year 2008 to fulfill a commitment under the Clean Smokestacks Act.

Type(s) of GHG Reductions

GHG reporting is an enabling mitigation option to encourage management, and ultimately reduction, of GHG emissions. GHG reporting does not reduce GHG emissions per se.

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[1] Defined as "Scope 1" emissions in the *GHG Protocol;* see www.ghgprotocol.org

[2] Defined as "Scope 2" emissions in the *GHG Protocol;* see www.ghgprotocol.org

[3] Defined as "Scope 3" emissions in the *GHG Protocol;* see www.ghgprotocol.org

Estimated GHG Reductions and Costs (or Cost Savings)

The reporting of GHGs under this mitigation option would help position sources for participating in an emissions trading program, should one develop in the future, leading to cost savings. Although establishment of a credible reporting program is essential for participating in a trading program, these elements do not reduce GHG emissions themselves.

Key Uncertainties

Uncertainties exist with respect to quantification of some GHG emissions from some sources, but standard quantification protocols are rapidly being developed and accepted widely. There remain significant uncertainties with respect to how various state, regional, and/or federal GHG reporting programs may develop, but the best way to affect these outcomes toward North Carolina's benefit may be engagement in these processes by the state now.

Additional Benefits and Costs

None cited.

Feasibility Issues

None cited.

Status of Group Approval

Complete.

Level of Group Support

Unanimous consent.

Barriers to Consensus

None.

CC-3. State Greenhouse Gas Registry

Mitigation Option Description

A GHG registry enables uniform calculation and recording of GHG emissions reductions in a central repository. Typically, a registry also includes transaction ledger capability in order to support tracking, management, and ownership of emission reductions. Registries can help encourage sources to undertake GHG reduction efforts, enable potential recognition for such actions, provide baseline protection, and support the crediting of GHG mitigation actions. A registry can also provide a mechanism for regional, multi-state, cross-border, and even global cooperation. Subject to appropriately rigorous quantification standards, participation in a GHG registry should not be constrained to particular sectors, sources, or approaches in order to encourage GHG mitigation activities of all types from all quarters. In particular, a GHG registry should be able to incorporate activities associated with all of the options that the CAPAG approves, whether reflective of reductions in emissions of GHGs or increases in biological or geological sequestration of carbon.

Mitigation Option Design

Goals: The TWG recommends that North Carolina actively engage with other states in developing a regional or national GHG registry that will comprehensively meet the state's needs. If developing regional or national multi-state registries do not initially include all of the state's preferred criteria, North Carolina should still join and participate to the greatest extent possible, and work to develop whatever additional registry capacity is necessary to meet the remaining needs of North Carolina sources (e.g., registration of carbon sequestered due to reforestation). Together, these approaches should cover all mitigation options the CAPAG recommends, provide adequate quality verification, and allow project-level reporting. Participation by North Carolina sources should be voluntary, and costs should be borne primarily by participants. Recommendations for key registry design characteristics build off the GHG Reporting mitigation option (CC-2). Key elements important to North Carolina include

- Geographic applicability at least at the statewide level and as broadly (i.e., regionally or nationally) as possible.
- Inclusion of as broad an array of sectors, sources, facilities, and approaches as possible.
- Allowing sources to start as far back chronologically as good data exists, as affirmed by third-party verification, and allowing registration of project-based reductions or "offsets" that are equally rigorously quantified.
- Incorporating adequate safeguards to ensure that reductions aren't double-counted by multiple registry participants, and providing appropriate transparency.
- Striving for maximum consistency with other state, regional, and/or national efforts; greatest flexibility as GHG mitigation approaches evolve; and providing guidance to assist participants.
- Allowing the state and its political subdivisions to be valid participants for registering reductions associated with their programs, direct activities, or efforts, including the

registration of emission reductions associated with the stationary and mobile sources they own, lease, or operate. Similarly, the state and its political subdivisions should also be allowed to participate in emission trading if and when such a program is developed and authorized. Revenues associated with the sale of any emission reduction credits generated by the state or its political subdivisions could be used to support the GHG emission inventory, forecasting, reporting, and registry functions within state government.

Timing: As soon as possible after a GHG reporting program is operating.

Parties Involved: Coverage should include all entities that can verify ownership of GHG emission reductions.

Other: The *GHG Registry Design Characteristics Matrix* provided in Annex A is reference material to, not explicitly part of, this mitigation option.

Implementation Mechanisms

Implementation of this program should probably be led by NC DENR. Costs should be shared by participants benefiting from the registry. State staff and that of any outside registry group/funding may be necessary.

Related Policies/Programs in Place

In May of 2007, the state of North Carolina became a charter member of The Climate Registry (TCR), along with 34 other states plus tribal members and Canadian provinces. Currently, the total membership of the TCR includes 40 U.S. states, two Canadian Provinces, one Mexico state, and three Tribal Authorities. The state is represented on the board of directors in the preparation of the protocols and rules by which the group will be governed. TCR board has expressed a goal to be open for business by the beginning of calendar year 2008. TCR is voluntary; however, it will facilitate states, tribes, or provinces choosing to make reporting mandatory for their sources.

North Carolina companies have also been major participants in the 1605 (b) registry that has been operated by the U.S. Department of Energy for several years and has led the state participation in that registry for a number of years. That effort is also voluntary and will likely continue.

Type(s) of GHG Reductions

Not applicable.

Estimated GHG Reductions and Costs (or Cost Savings)

Not applicable.

Key Uncertainties

There remain significant uncertainties with respect to how various state, regional, and/or federal GHG registry programs may develop. Involvement in early registry implementation—as issues are deliberated among states—will be an advantage to North Carolina in their ultimate outcome.

Additional Benefits and Costs

None cited.

Feasibility Issues

None cited.

Status of Group Approval

Complete.

Level of Group Support

Unanimous consent.

Barriers to Consensus

None.

CC-4. State Climate Public Education and Outreach

Mitigation Option Description

Public education and outreach can support greenhouse gas (GHG) emissions reduction efforts at the macro- or micro-scale in relation to emissions reduction programs, policies, or goals. Public education and outreach is vital to fostering a broad awareness of climate change issues and effects (including co-benefits, such as clean air and public health) among the state's citizens. Such awareness is necessary to engage citizens in actions to reduce GHG emissions. Public education and outreach efforts should integrate with and build upon existing outreach efforts involving climate change and related issues in the state. Ultimately, public education and outreach will be the foundation for the long-term success of all the mitigation actions proposed by the CAPAG as well as those which may evolve in the future.

Mitigation Option Design

Goals: The TWG recommends that the state lead by example in its own education and outreach activities by establishing a pro-active public education and outreach capability to assist in the implementation of CAPAG mitigation options adopted by the Governor.

- Education and outreach activities would target five specific audiences:
  - Policymakers and managers (legislators, regulators, executive branch, agencies, and employees)—because implementation of climate actions hinges on approval by policymakers and implementation by managers;
  - Educators and Students—by integrating climate change into primary and secondary educational curricula, post-secondary degree programs, and professional licensing programs;
  - Community Leaders and Community-Based Organizations (e.g., institutions, municipalities, service clubs, social and affinity groups, and non-governmental organizations)—to recognize leadership, share success stories and role models, and expand climate involvement and participation within civic society;
  - General Public—to increase awareness and engage citizens in climate actions in their personal and professional lives; and
  - Industrial and Economic Sectors—to recognize leadership, share success stories and role models, and expand climate involvement and participation within the business community.

Timing: Public education and outreach efforts should commence as rapidly as possible.

Parties Involved: A statewide public education and outreach effort should probably be overseen largely by NC DENR, but would necessarily involve many other key parties.

Other: The *Education Design Characteristics Matrix* provided in Annex A is reference material to, not explicitly part of, this mitigation option.

Implementation Mechanisms

Public education and outreach. Additional staff and/or funding may be necessary depending on the extent of the public education and outreach effort.

Related Policies/Programs in Place

DENR efforts and standard course study.

Type(s) of GHG Reductions

Not applicable.

Estimated GHG Reductions and Costs (or Cost Savings)

Not applicable.

Key Uncertainties

- Timing and degree of federal and private sector recognition and support through awareness, acknowledgement, and quantification of climate change risk.
- Availability of sustained funding for education and outreach.

Additional Benefits and Costs

- Costs: Office establishment, travel for training programs, program materials.
- Benefits: For example, reduced landfill inputs, improved air/water quality, enhanced business opportunities, and reduced congestion and highway infrastructure costs.

Feasibility Issues

Logistics for coordination between agencies and the public; funding for education and outreach.

Status of Group Approval

Complete.

Level of Group Support

Unanimous consent.

Barriers to Consensus

None.

CC-5. State Climate Change Adaptation Strategy

Mitigation Option Description

Due to the existing buildup in the atmosphere of GHGs that has already occurred, North Carolina will experience some effects of climate change for years to come, even if immediate action is taken to reduce future GHG emissions. Thus, it is essential that the state develop a plan to manage the projected impacts of ongoing climate change while worldwide mitigation efforts to lower atmospheric concentrations are underway.

Mitigation Option Design

While taking action to reduce GHG emissions in North Carolina, the state should develop, adopt, and implement a state Climate Change Adaptation Plan that includes identification of (a) potential short-term, mid-term, and long-term impacts of climate change scenarios likely to affect the state and (b) implementation mechanisms for addressing these impacts. The state should empanel a "Blue Ribbon" Commission on Adaptation to Climate Change to develop a state Climate Change Adaptation Plan within one year of establishment of the Commission. The Commission should involve and coordinate with all appropriate state and local agencies, organizations, and institutions (e.g., universities) to ensure that all potential impacts are identified in the plan. The Commission should also enlist the expertise of all appropriate state and local agencies, organizations, and institutions in developing and implementing measures for mitigating these impacts. As a minimum, the Commission should address the adaptation issues in the plan that the CAPAG has identified in the table that accompanies this mitigation option.

The state Climate Change Adaptation Plan should include at least the following key elements:

- Comprehensive identification of potential short-term, mid-term, and long-term impacts associated with climate change in North Carolina.
- Recommended steps to respond to the identified impacts so as to minimize risk in North Carolina to humans, natural and economic systems, water resources, temperature-sensitive populations and systems, energy systems, transportation systems, communications systems, vital infrastructure and public facilities, and natural lands (such as coastal areas, wetlands, forests, and farmland) and all other identified and affected sectors or areas of concern throughout the state.
- Coordination of response efforts through the appropriate state, local and federal agencies, organizations, or other entities or initiatives.
- Characterization of the potential risks and costs of inaction; characterization of the potential costs, benefits, and co-benefits associated with specific policy and program actions; and establishment of time- and program-based goals.
- Use of cost-benefit analysis to guide and inform the development and implementation of the state Climate Change Adaptation Plan. The analysis should include, but not be limited to, an examination of the benefits and costs of adaptation measures or responses relative to a "status quo" or no-action approach, and the resources needed to implement adaptation measures in the plan. The results of the benefit-cost analysis should also be used to set priorities for

addressing short-term, mid-term, and long-term impacts of climate change on citizens, ecosystems, and the economy of North Carolina.

- Adaptation measures that also mitigate GHG emissions should be given priority in the state Climate Change Adaptation Plan.
- Regular review and update of the Plan on a periodic basis (e.g., every 5–10 years) to expand or refine the Plan as necessary, to improve implementation of the Plan, and to incorporate new information as it becomes available.

The state Legislature should provide funding to support development and on-going revision to the state Climate Change Adaptation Plan including, but not limited to, funds to support the benefit-cost analysis needed to guide and inform the development and implementation of the Plan and to cover expenses incurred by the Commission and Commission members.

Goals: Create a state-sanctioned Blue Ribbon Commission on Adaptation to Climate Change to develop a comprehensive state Climate Change Adaptation Plan identifying opportunities to address adaptation issues and risks and recommending tangible, implementable measures to ameliorate these issues and risks to North Carolina citizens. Conduct benefit-cost analyses to compare the potential costs of a "status quo" approach as opposed to implementing the recommendations proposed in the Climate Change Adaptation Plan. Prioritize recommendations in the adaptation plan based on the certainty and severity of adverse impacts to citizens, ecosystems and local economies. Development of the plan should (a) involve all affected agencies and entities at all levels of government; (b) involve all affected sectors and interests; and (c) provide for periodic review and update concerning adaptation risks, responses, and opportunities in the state.

Timing: The Commission should be established as soon as possible. The development of a state Climate Change Adaptation Plan should be completed within one year of establishing the Commission. Benefit-cost analyses of the potential costs of a "status quo" approach as compared to implementing the Plan's recommendations should be conducted as a component of the plan. Parallel public education and outreach efforts regarding adaptation should commence immediately. "Early-adoption" opportunities should be addressed as rapidly as possible (even before the Commission is established, if possible), and pro-active adaptation initiatives should commence within the next 2–3 years.

Parties Involved: The Blue Ribbon Commission on Adaptation to Climate Change should involve and coordinate with all appropriate state and local agencies, organizations, and institutions (e.g., universities) to ensure that all potential impacts are identified and to ensure the successful development and implementation of the plan.

Other: The *Adaptation Issues Matrix* provided in Annex A is reference material to, not explicitly part of, this mitigation option.

Implementation Mechanisms

- State Climate Change Adaptation Strategy.
- Public education and outreach.
- Development of mitigation recommendations as necessary.

- Establish financial structures and create markets that are likely to thrive under anticipated climate impacts.

Related Policies/Programs in Place

- State and local emergency management response plans are in place that address short-term responses to natural disasters (e.g., violent storms). To the extent possible, measures recommended in the Climate Change Adaptation Plan should assist and complement these existing state and local efforts.
- Efforts are being undertaken by the North Carolina Division of Coastal Management (DCM) to require that all coastal counties address and respond to the impact of sea level rise in land use plans. DCM also requires setbacks from the oceanfront and prohibits hardened structures on the oceanfront. DCM allows hardened structures along estuarine waters and requires a 30-foot setback for all structures except those that are water dependent. Measures for responding to sea level rise proposed in the Climate Change Adaptation Plan should assist and complement these existing efforts.

Type(s) of GHG Reductions

Not applicable.

Estimated GHG Reductions and Costs (or Cost Savings)

Not applicable.

Key Uncertainties

Some impacts of climate change, such as sea level rise and inundation of low-lying coastal lands are certain, but their specific timing and magnitude remains unclear. Other impacts are less certain and may have significant variability.

Additional Benefits and Costs

- Innovative early adaptation responses to climate change impacts can be designed to
  - Help prevent and/or reduce costs associated with future catastrophic events and long-term climate change impacts;
  - Direct future public and private investment more effectively; and
  - Ensure preparedness to help avoid extensive cost implications to state, county, city and federal agencies.
- Early preparedness can raise public awareness and encourage further GHG mitigation efforts, which can drive economic opportunities for alternative fuels, agriculture, forestry, and advanced technologies.

Feasibility Issues

None cited.

Status of Group Approval

Complete.

Level of Group Support

Unanimous consent.

Barriers to Consensus

None.

CC-6. Options for State Greenhouse Gas Goals or Targets (for CAPAG in support of LCGCC)

Mitigation Option Description

Many anticipate that eventually the federal government will legislate some cap on greenhouse gas (GHG) emissions associated with global warming. A number of states are ahead of the federal government in establishing GHG caps. For example, the Northeastern States (including New York) have instituted a regional cap and trade program to reduce power-sector GHG emissions. California has recently signed into law an economy-wide cap.

North Carolina has successfully severed the link between increasing energy consumption and emissions of soot and smog-forming pollution; even as energy consumption increases, sulfur dioxide and nitrogen oxide pollution are being significantly decreased.

Now North Carolina should establish voluntary goals to limit GHG emissions to prepare the state's economy for the likely caps at the national level, and begin to sever the link between increasing energy demand and GHG emissions. Even modest reductions in GHG emissions will help to align North Carolina's environmental and economic interests, and assist the state in addressing its contribution to global warming. The goal would not be mandatory, but simply sets a direction in GHG emissions, just like the NC million acre conservation goal.

Mitigation Option Design

Goals: The voluntary goal should be set to bring emissions back to a baseline, such as year 2000.

Timing: The goal should be set over a long-time horizon of 10–15 years to meet the baseline. It should be expressed as an interim goal on the longer path toward ultimate climate stabilization.

Parties Involved: This would be an overall voluntary goal for the State of North Carolina. There would be no mandates to any specific party. However, all sectors of the state's economy would have the opportunity to contribute toward meeting the state's goal.

Implementation Mechanisms

The adoption of such a goal should first be considered by the NC Legislative Commission on Global Climate Change (LCGCC). If recommended by the LCGCC, such a goal could be established by the General Assembly or by an executive order of the Governor.

Related Policies/Programs in Place

None cited.

Type(s) of GHG Reductions

Include all GHGs and black carbon.

Estimated GHG Reductions and Costs (or Cost Savings)

This mitigation option would be established in conjunction with other options and programs. Thus, it is very difficult to estimate the GHG reduced specifically from this mitigation option. As the goal would be voluntary, the cost per $MMtCO_2e$ is anticipated to be quite small and perhaps may create a positive economic benefit.

Key Uncertainties

- Timing and levels of federal standards to cap GHGs.
- Emission inventory by sector of GHGs. A goal would work best in conjunction with a GHG emission reporting program.
- Availability and cost of new and improved GHG-associated technologies.

Additional Benefits and Costs

The benefits of passing this state goal legislation are fivefold:

- **Addressing Potential Global Warming Impacts—**The direct economic toll of global warming on North Carolina may be enormous and would likely include increasing: crop loss due to drought, episodic water shortages, coastal flooding and erosion, and building cooling costs. A state goal will draw attention to regional warming trends and associated effects and help business and government prepare for the future.
- **Economic Development—**As the state plans its economic development activities, a state carbon reduction goal can help promote expansion and recruitment of renewable energy technologies that are less GHG-intensive. Additionally, these activities will seek to generate jobs in North Carolina to replace the non-native coal and gas sources that currently dominate North Carolina's energy supply.
- **State Leadership—**By establishing a state goal, North Carolina will join the numerous states across the country that are already rising to the challenge of addressing GHG emissions associated with global warming.
- **Business Responsibility—**A state goal will be to provide the motivation and opportunity for companies to examine their options for cost-effective reductions in their GHG emissions. Many companies in North Carolina are already considering the need to reduce carbon dioxide in their long-term planning. A reduction goal will foster the broader business community to consider their ability to also reduce GHG emissions.
- **Preparing for the Emerging Carbon Marketplace—**North Carolina business can potentially sell tens or even hundreds of millions of dollars worth of carbon equivalence credits into the carbon marketplace that national climate legislation will likely eventually generate. A state goal would help companies that could potentially be suppliers of carbon credits in the coming national marketplace prepare to take advantage of these economic opportunities as soon as they arise.

Feasibility Issues

The mitigation option is simple, straightforward and voluntary. The goal can be an expression of commitment by the state of North Carolina to address the challenge of global warming through voluntary reductions in GHG emissions.

Status of Group Approval

Complete.

Level of Group Support

Unanimous consent.

Barriers to Consensus

None.

Annex A to Cross-Cutting Issues Mitigation Option Descriptions
Reference Materials

Cross-Cutting Issues Technical Working Group
GHG Inventories and Forecasts Design Characteristics Matrix

Purpose and Goals of Inventories and Forecasts:

Tracking GHG emissions trends
Identifying opportunities and areas for action
Others?

	Design Element	Options	Design Considerations	Preliminary Recommendation
1.	**Responsibility for Preparing Periodic Inventories and Forecasts**	Sole responsibility with NC DENR Department of Air Quality (DAQ) Shared responsibility between DAQ and other state agencies	Purpose is to develop consistent, systematic inventories and forecasts from one year to the next. Subject matter expertise is evolving rapidly.	• DAQ has substantial emissions inventory responsibility now, so recommend locating responsibility and authority for this function at DAQ as well. • Inventories and forecasts should include all sectors/sources. • Responsibility of other agencies to provide DAQ with related data and assistance (e.g., VMT) must be explicit.
2.	**Inventory Frequency**	Annual Other	Inventory reflects historical emissions. Different sized sources currently required to report emissions on different schedules (e.g., major sources annually; minor sources every 5 years). Must be consistent with any NC GHG Reporting Program, and should strive for consistency with other inventory and forecasting programs.	• Prepare comprehensive, thorough recalculation every 5 years. • Publish inventory update annually based on readily available data (e.g., emissions filings from major sources and periodic filings of minor sources) for calendar year. • Starting year: Use CAPAG inventory and forecast for past data and 2005; prepare comprehensive revisions in 2010, 2015, 2020, and so on. • Dovetail to the extent possible with existing CSA requirements. • DAQ to receive public input and comment before finalizing.

	Design Element	Options	Design Considerations	Preliminary Recommendation
3.	**Forecast Frequency and Periods**	Annual Intervals Other	Forecasts reflect estimates of future emissions. Define future years for which emissions inventory is prepared (e.g., frequency and overall forecast period). Define intervals for future year forecasts (e.g., annual, 5-year intervals relative to a base historical year). Limitations exist on availability of activity data for projecting emissions (e.g., current Energy Information Administration (EIA) projections of fuel consumption only go to 2025). Should strive for consistency with other inventory and forecasting programs.	• Prepare comprehensive, thorough recalculation every 5 years, alongside inventory. • Publish forecast update annually based on readily available data (e.g., emissions filings from major sources and periodic filings of minor sources) for calendar year. • Project as far into the future as reasonably possible (e.g., 5, 10, 15, 20, 25, and 50 years). • Dovetail to the extent possible with existing CSA requirements. • DAQ to receive public input and comment before finalizing.
4.	**Greenhouse Gases Included**	Six "Kyoto gases" (CO_2, HFCs, CH_4, N_2O, PFCs, SF_6) Black Carbon	Must be consistent with any NC GHG Reporting Program, and should strive for consistency with other inventory and forecasting programs. Broader array promotes inventory building, public information, identification of GHG strategies, and so on.	• Include mass emissions of the six "Kyoto gases" and black carbon. • Calculate CO_2-equivalence to the extent possible.

	Design Element	Options	Design Considerations	Preliminary Recommendation
5.	**Basis for Calculating and Reporting Emissions**	Production based Consumption based	Production refers to emissions generated by sources in-state (e.g., emissions from power generated in-state whether consumed in-state or exported). Consumption refers to "Production" based emissions plus imports and minus exports, at least for the energy sector.	• Recommend calculating emissions on both production and consumption bases to the extent reasonably practicable.
6.	**Emissions Quantification**	Calculation methods & tools Federal 1605(b) program details quantification of black carbon emissions.	Apply current best practice methods (e.g., *GHG Protocol* and calculation tools). Strive for consistency with other reporting and quantification programs. Some "other" or "home grown" approaches may be necessary (e.g., Flashing emissions; IPIECA[1], API's[2] SANGEA™ GHG Emissions Software).	• Recommend quantifying emissions on the basis of best available practices, minding the importance of consistency with other programs, and transparently noting any necessary departures or changes.
7.	**Public Access & Reports**	• Internet access and/or Online reports • Paper reports • Both		• Recommend DAQ make inventories and forecasts readily available to policymakers, interested parties, and the general public via the Internet.

[1] IPIECA is the International Petroleum Industry Environmental Conservation Association.
[2] API is the American Petroleum Association.

	Design Element	Options	Design Considerations	Preliminary Recommendation
8.	**Funding**	• State-funded. • Emission-based fees (would require legislative approval). • Some combination? • Other?	Inventories and forecasts can only be accomplished if adequate DAQ resources exist, so creative funding sources should be investigated (e.g., transaction fees and GHG credit sales).	• DAQ should publish the initial annual update based on CAPAG inventory and forecast. • Simultaneously, DAQ should consult with interested parties to identify, weigh, and select among creative funding approaches.
9.	**Periodic Reassessment of Inventory and Forecast Approach**	• Authority • Purpose • Frequency	DAQ and involved agencies should have the ability to periodically reassess and revise (if necessary) designs element of the inventory and forecasting program. Sample reassessment considerations: o Relative impact of sources or groups on overall emissions totals vs. costs of calculating their emissions. o Benefits to NC air, taxpayers, businesses?	• DAQ should review at 5-year intervals following implementation of the GHG inventory and forecast program. • DAQ's review should identify any revisions necessary and appropriate next steps and/or research questions.
10.	**Other?**			

Cross Cutting Issues Technical Working Group
GHG Reporting Design Characteristics Matrix

WRI/WBCSD *GHG Protocol*'s
Principles for GHG accounting and reporting:

1. Relevance
2. Completeness
3. Consistency
4. Transparency
5. Accuracy
6. Enable other goals

Potential Goals of GHG Reporting:

1. Identifying reduction opportunities
2. Reducing risks (e.g., start learning curve)
3. Tracking GHG emissions, assisting the state in constructing annual inventories
4. Participating in voluntary programs
5. Participating in—or preparing for—mandatory programs
6. Precursor for registry participation
7. Opportunities for recognition
8. Public reporting
9. Consistency with other programs
10. Others?

	Design Element	Characteristics	Design Considerations	Preliminary Recommendation
1.	**Type of Program**	Voluntary Mandatory	May need or want to constrain mandatory applicability to certain sectors and/or sources pending availability of accepted quantification protocols. Mandatory reporting is in place in some states for sources subject to a state air permit (e.g., ME, and CT); anticipated soon for several others in Northeast and far West.	
2.	**Sectors**	All sectors eligible Limited to certain sectors	Participation may be limited by availability of quantification methods; may need to "stage" sector participation. WRI calculation protocols: Stationary combustion, mobile, electric power, cement, iron & steel, aluminum, pulp & paper, wood products, lime, ammonia, purchased heat or power, others.	
3.	**Sources**	All Stationary combustion emissions Mobile combustion emissions Process emissions Fugitive emissions	Could limit sources even within sectors, (e.g., via types and size thresholds). Broader array promotes inventory building, public information, identification of GHG strategies, and so on.	• From catalog 2.5: Require mandatory GHG reporting for permitted sources.
4.	**Organiza-tional Boundary**	Entity-wide (e.g., corporation-wide) Facility Emissions unit or source point Other (?)	Clear definitions needed to avoid double counting where shared ownership exists. Should strive to have design be consistent with possible future directions (e.g., mandatory reporting would not be enforceable above the facility level). Combinations are possible (e.g., finer resolution aggregated to a greater whole).	• From catalog 2.2: Report NC emissions from state facilities & vehicles to public & 1605(b).

	Design Element	Characteristics	Design Considerations	Preliminary Recommendation
5.	**Reporting Period**	Annual • Calendar • Fiscal Other	Should strive for consistency with other reporting programs.	
6.	**Greenhouse Gases Included**	Six "Kyoto gases" (CO_2, HFCs, CH_4, N_2O, PFCs, SF_6) Black Carbon Other	Should strive for consistency with other reporting programs. Broader array promotes inventory building, public information, identification of GHG strategies, and so on.	• From catalog 2.3: Include non-CO_2 GHGs.
7.	**Scope of Emissions Covered**	Direct • "Scope 1" Indirect • "Scope 2" - Indirect from purchased Heat & Electricity • "Scope 3" - other indirect (e.g., outsourced activities and employee travel) Both	May need or want to "stage" coverage (e.g., start small & expand). Direct emissions most like current reporting requirements, but may omit GHG reduction opportunities or encourage direct-indirect trade-offs. For many entities, most GHG emissions are from indirect emissions sources.	
8.	**Emissions Quantifi-cation & Monitoring**	Calculation methods & tools Direct measurement (e.g., CEMs, Stack Testing)	Should strive to use current best practice methods, such as *GHG Protocol* calculation tools, and to have consistency with other reporting programs. Some "other" or "home grown" approaches may be necessary (e.g., Flashing emissions; IPIECA[3], API's[4] SANGEA™ GHG Emissions Software).	

[3] IPIECA is the International Petroleum Industry Environmental Conservation Association.
[4] API is the American Petroleum Association.

	Design Element	Characteristics	Design Considerations	Preliminary Recommendation
9.	**Verification**	• State verification • 3rd party verification • Self-certification	If mandatory, the state may be able to use current verification procedures for criteria pollutants. DAQ does 3rd-party verification.	
10.	**Public Access & Reports**	• Internet access and/or Online reports • Paper reports • Both	"Confidential Business Information" (CBI) concerns.	
11.	**Project Level Reporting or "Offsets"**	• Yes/No • Constrain	WRI: Raises quantification, baseline, "additionality," secondary effects, reversibility, and double-counting issues. Location of co-benefits achieved. May be most useful when there is an externally-imposed constraint (e.g., a "Cap").	
12.	**Funding**	• State-funded • Mandated requirement • Emission-based fees (would require legislative approval). • Other? A combination?	Reporting is a necessary cornerstone for a GHG registry, so it may be appropriate to have registry participants share support costs.	
13.	**Others?**			

Cross Cutting Issues Technical Working Group
GHG Registry Design Characteristics Matrix

Notes:

- Builds upon GHG Reporting Design Characteristics Matrix.
- Some Reporting preferences could be outweighed by Registry preferences (e.g., if a regional registry has different specs).

Potential Goals of GHG Registry:

1. Recording of GHG reductions (vs. emissions)
2. A central, independent repository for credible info about emissions activities
3. A "transaction ledger" – providing data management & accounting critical for trading (with or without a cap)
4. "baseline protection" – enabling early action current or future credit for trading
5. An incentive to track & manage emissions, seek productivity and energy efficiency gains, accelerate learning curve regarding competitiveness & carbon markets
6. Enhance public recognition & demonstrate corporate citizenship
7. Possible vehicle for regional, multi-state & cross-border cooperation
8. Others

	Design Element	Characteristics	Design Considerations	Preliminary Recommendation
1.	**Key Design Criteria (beyond *GHG Reporting Design Characteristics Matrix*)**			
1.1	Define geographical boundaries	• North Carolina • Regional (or broader)	• Span of control. • Cost, economies of scale, & broader = better?	
1.2	Verification	• State verification • Third-party verification	• See GHG Reporting. Design Characteristics Matrix.	
1.3	Base Year	• Single specified year • Single entity-chosen year • Average of multiple years • Adjustment rules?	• Flexibility vs. Simplicity. • Must have good data for Base Year.	
1.4	Project-level submittals	• Yes / No / Constrain	• Against what baseline? • Additionality issues (what would have happened anyway)?	
1.5	"Offsets"	• Yes / Some / No	• Co-benefits location? • Nature / character?	
1.6	Start Date		• Establish a "to be in operation" date?	
1.7	Ownership		• Risk of double-counting.	
1.8	Transparency			
1.9	Others?			

	Design Element	Characteristics	Design Considerations	Preliminary Recommendation
2.	**Technical Issues**			
2.1	Treatment of minority ownership		• GHG Protocol	
2.2	Merger & acquisition issues		• GHG Protocol	
2.3	Quality Assurance; Uncertainty Analysis		• GHG Protocol	
2.4	Regulatory guidance (e.g., protocols and guidance documents)			
2.5	Data flow; filing methods, etc.		• Confidential business information (CBI), legal authority, and so on.	
2.6	Others?			
3.	**Ancillary, Administrative, & Operational Issues**			
3.1	Location (Agency)	• NCDENR • Other?	• Regional potential.	
3.2	Software; Web Interface, etc.	• North Carolina-specific • CCAR, RGGR, CCX, ERT, EATS? • Other?	• Multiple needs (e.g., emissions inventory, allowances, mandatory, or voluntary). • Rapidly changing "state of the art."	
3.3	Cost	• Transaction fee • Publicly supported? • Other?	• Development costs. • Ongoing operating costs.	

	Design Element	Characteristics	Design Considerations	Preliminary Recommendation
3.4	Oversight & Management	• NCDENR • Publicly appointed board • Other?		
3.5	Reporting of Results; Recognition			
3.6	Others?			

Cross Cutting Issues Technical Working Group
Education Design Characteristics Matrix

The recommendations and options in this matrix originate in large part as a result of "Recommendation A-7" in the September 1, 2005 Clean Smokestacks Act report and State Energy Plan (SEP).

Goals of Public Education & Outreach:

1. Overarching goal: Promote awareness among citizens about the impacts of climate change, solutions, and co-benefits of action.
2. Education provides a foundation essential for all climate action.
3. Others?

General Approach:

1. Target the key general audiences and efforts below:
   a. "Walking the Talk" in terms of the state's own efforts and outreach activities;
   b. Policymakers (e.g., legislators, executive, agencies, and regulators);
   c. Future Generations;
   d. Community Leaders and Organizations;
   e. Business and Industry;
   f. The General Public.
2. Ensure long-term sustenance of education and outreach efforts regarding climate change.

	Measures & Strategies	Tasks & Examples	Notes & Elaborations
1.	**State Government Actions** The state should lead by example (i.e., "walk the talk") regarding education and outreach.		
1.1	Create a multi-agency Board (or Office of Climate Change Impacts and Mitigation) to oversee on-going state climate efforts, starting with the implementation of CAPAG mitigation options adopted by the Governor; report progress to the public annually.	• Assemble annual progress reports & make them publicly available.	• Staff the effort adequately; should have one or more "outreach coordinators" specifically tasked with outreach and coordination among agencies and organizations. • Such a Board could also help avoid duplication of efforts in the state.
1.2	Establish an Education & Outreach Subcommittee of the body established in §1.1 to educate audiences regarding CAPAG policies, and to oversee those relating to education.	• Lead implementation of CAPAG education & outreach measures. • First task: Identify already existing resources & programs. • Identify additional needs and potential funding sources.	
1.3	Include state public education and higher education officials in the bodies established in §1.1 & §1.2.	• NC Department of Public Instruction develop teacher training and curriculum.	• A "two-way street": education officials bring research & info to the body; act as outreach arm for reaching students and others. • Post resources online that include hands-on activities such as reducing carbon footprints.
1.4	Educate state employees across-the-board, and assign "point persons" to do so on an on-going basis.	• Identify agency liaisons for the multi-agency Board or Office of Climate Change Impacts and Mitigation.	• One possibility: Add climate change outreach as a natural extension to the existing role of Agency Energy Managers.

	Measures & Strategies	Tasks & Examples	Notes & Elaborations
1.5	Disaggregate the state's GHG emissions to the agency level and require annual agency-specific reports on GHG reduction progress.		• Make agency-specific reports public as part of the report in §1.1.
2.	**Target Audience: Policymakers (legislators, regulators, executive branch, agencies)** **I**mplementation of climate actions hinges on policymakers' understanding and approval.		
2.1	Educate policymakers on climate change & CAPAG policies in order to promote acceptance and implementation.	• Conduct regular legislative briefings. • Identify & offer agency-specific info on climate issues & opportunities.	• Use input derived from policymaker interactions to develop new mitigation measures going forward.
2.2	Provide continuing outreach & assistance to Governor's office, legislature, and implementing agencies on a regular basis.	• Educate press liaisons from agencies and so on • Provide regular press releases or updates on reductions, events, and so on.	
3.	**Target Audience: Future Generations** Integrate climate change into educational curricula, post-secondary degree programs, and professional licensing.		
3.1	Organize groups of educators to identify, assemble, and employ climate change curricula appropriate to age groups.	• Work with the Department of Public Instruction for guidance.	• Check out British Petroleum's www.aplusforenergy.org.

	Measures & Strategies	Tasks & Examples	Notes & Elaborations
3.2	Public Education Department: include climate change in science and social studies performance standards; identify (a) gaps in climate change education, and (b) curriculum to fill any gaps.	• Include concepts of locally grown food, global population impacts, and so on. • Incorporate renewable energy and energy efficiency technology into physics curriculum. • Create "climate backpacks" to be used as teacher tools. • Link current environmental curriculum to climate change (e.g., carbon reduction benefits of recycling, conservation, and tree planting).	
3.3	Integrate "best practices" into public school design & construction to educate student (and parent's) first-hand in their communities & colleges (i.e., walk the talk).	• Investigate whether North Carolina could provide bonding for school districts to fund energy efficient construction. • Include in-building signage & displays to explicitly point out efficiency aspects built in to public buildings.	
3.4	Promote research into climate change and solutions at state universities.	• Provide funding for climate change research, award scholarships.	• Include research money for social justice implications of climate change (not just science).
3.5	Integrate climate change into existing and/or new educational competition programs (e.g., Envirothon and science fairs).		
3.6	Work with science centers, zoos, and museums to include a climate science focus appropriate to their core mission.	• A key area for an Outreach Coordinator to focus on.	• Examples exist in other regions (e.g., Clean Air-Cool Planet science center initiative). • Could provide speaking opportunities for teachers; have college professors host forums for high school students on weekend, etc.

	Measures & Strategies	Tasks & Examples	Notes & Elaborations
3.7	Introduce core competencies on climate change into professional licensing programs (e.g., energy efficiency in building design and construction and use of recycled materials).	• Promote the calculation of carbon footprints and creating a carbon reduction plan.	
4.	**Target Audience: Community Leaders & Community-Based Organizations** (Institutions, municipalities, service clubs, social & affinity groups, NGOs, etc.) Recognize leadership; share success stories & role models; expand involvement and participation; within civic society.		
4.1	Identify individual community leaders who are acting effectively on climate change; showcase and share their successes.	• Enlist/encourage them to be a de facto "speakers' Bureau." • Host discussion forums featuring them.	• Include all walks of work and life (e.g., retail, services, manufacturing, healthcare, auto, and facilities). • Put examples (such as guidance, links, and contacts) up on the Web clearinghouse.
4.2	Identify "late bloomer" individuals and target a special effort to include, educate, and prod them to act.		
4.3	Engage associations and participate in their meetings periodically to educate them about climate change and sector-specific mitigation actions.		
4.4	Develop statewide recognition program(s) for community leaders and entities.		
4.5	Organize & host outreach events that focus on leading by example, sharing how-to, co-benefits, illuminating financial risks and opportunities, and so on.		

	Measures & Strategies	Tasks & Examples	Notes & Elaborations
4.6	Identify, assist, and leverage community-based organizations with expertise or interest in climate-related issues.	• Faith community • Service clubs; sportsmen; recreational/hobbyist groups • Metropolitan planning organizations • environmental, social, & civic advocacy organizations	
4.7	Work with community-based organizations to identify & build upon climate issues related to their core mission.	• Public health vs. new disease vectors? • Low-income vs. additional stressors?	
4.8	Support and facilitate outreach and education within community-based organization regarding climate change issues and actions.	• Provide content for websites, newsletters, List Servs? • Coach & assist community Outreach coordinators?	
4.9	Develop & coordinate a network of community-based organizations acting on climate change so they can link up, organize joint events, and so on.	• Community Outreach coordinators? • Assistance in organizing	
4.10	Encourage cities to join ICLEI's[5] Cities for Climate Protection program.		• (Formerly 4.14 on CC Catalog).
4.11	Encourage cities to join the US Mayors Climate Protection Agreement.[6]		• (Formerly 4.15 on CC Catalog).
5.	**Target Audience: Business and Industry** Promote best practices, recognize leadership; share success stories & role models; expand involvement and participation.		

[5] See www.iclei.org.
[6] See http://www.ci.seattle.wa.us/mayor/climate/.

	Measures & Strategies	Tasks & Examples	Notes & Elaborations
5.1	Extend training programs for RCI building and facility operators.		• (Formerly 4.5 on CC Catalog). • From "Recommendation A-1" and "Recommendation LT-1" in the 9/1/05 CSA report.
5.2	Promote energy-tech economic development.		• (Formerly 4.3 on CC Catalog).
5.3	Promote R&D & demo projects for economic development.		• (Formerly 4.4 on CC Catalog).
5.4	Promote combined heat and power (CHP) in order expand its use and technological penetration.		• (Formerly 4.8 on CC Catalog). • From "Recommendation A-1" in the 9/1/05 CSA report.
5.5	Inform sources of the advantages of registering GHG emission reductions.		• (Formerly 4.13 on CC Catalog). • From "Recommendation A-4" in the 9/1/05 CSA report.
5.6	Develop and provide concrete information on co-benefits to entities in order to boost their climate efforts.		
6.	**Target Audience: General Public** Increase awareness and engage in climate actions in personal and professional lives.		
6.1	Educate broadcasters, reporters, editorial boards, etc. about climate change, the risks it imposes, and solutions.		
6.2	Work with state broadcasters and print media associations to develop & run climate change public service announcements; post billboards.		

	Measures & Strategies	Tasks & Examples	Notes & Elaborations
6.3	Conduct public polling to benchmark strength and depth of climate understanding; track over time to measure progress and better tailor outreach efforts.		
6.4	Keep a high profile on climate change issues and actions through regular public mention by Governor and other public leaders.		
6.5	Develop and use a state-based "brand" on climate awareness and action.		
6.6	Develop & maintain a state climate change website for the public; establish & maintain a web-based clearinghouse for climate change information and education resources.	• Link to scientific developments, What you can do, How you can help, What the state is doing, etc.	• Post annual progress reports on commitments, plan implementation, etc.
6.7	Reinforce sources (causes) of GHG emissions, and the need to implement the State Energy Plan.		• (Formerly 4.1 on CC Catalog). • From Recommendation LT -2 in the 9/1/05 CSA report.
6.8	Work with existing, company-outreach efforts to customers (e.g., utilities) to enhance awareness of climate change issues & actions.	• Retail advertising and/or "bill stuffers" • Environmental disclosure of electricity fuel mix/emissions; recycled content, etc. • Product messages (e.g., yogurt labels)	

	Measures & Strategies	Tasks & Examples	Notes & Elaborations
6.9	Promote local farm produce.	• Advertise hours and locations of farmers' markets • Encourage local grocery stores to stock local food items	• *(Formerly 4.10 on CC Catalog).* • Appendix D – Preliminary Analysis of Selected Mitigation Option Options: Agriculture and Forestry, Support Local Farming/Buy Local.
6.10	Promote clean fuel technologies.		• (Formerly 4.2 on CC Catalog).
6.11	Promote green power in order to expand subscription.	• Include subscription information in every monthly utility bill	• *(Formerly 4.7 on CC Catalog).* • *From "Recommendation A-5" in the 9/1/05 CSA report.*
6.12	Require environmental disclosure on utility bills.		• (Formerly 4.9 on CC Catalog). • From Appendix C – January 2005 Revisions to the State Energy Plan (SEP), Alternative Energy Sources: Exec-10.
6.13	Add GHG to Air Awareness efforts.		• (Formerly 4.12 on CC Catalog). • From "Recommendation A-7" in the Sept. 1, 2005 CSA report and State Energy Plan (SEP).
6.14	Host a training/informational table at Earth Day, or create a "Climate Day" event.	• Provide activities and educational materials for all age groups and expertise levels	
6.15	Develop a speaker's bureau.	• Include experts from each sector (Agriculture, forestry, energy, waste, faith, tourism, business, education, etc.).	
6.16	Develop a carbon calculator (web-based).	• Accommodate for calculating family homes, businesses, schools, and public buildings.	

	Measures & Strategies	Tasks & Examples	Notes & Elaborations
6.17	Create a tax credit Web site.	• Provide a one-stop resource for all available state and federal tax credits (e.g., auto or home energy) for consumers who are making global warming pollution reductions.	

Cross Cutting Issues Technical Work Group
Adaptation Issues Matrix

	Issue	Potential Effects or Impacts	All Possible Responses	Preliminary Recommendation
A. Coastal Resources				
1.	**Tropical Storms**	• Loss of barrier islands, property damage, disruption to local and regional economies and tourism, higher insurance rates.	• Buyout of land in hazardous areas, upgrade building codes, state insurance pool, beach nourishment, and retreat from highest risk barrier islands and low-lying lands. • Develop a beach and inlet management plan (underway).	• The General Assembly should enact legislation to require sellers of coastal properties to disclose potential hazards to buyers. The coastal hazards disclosure should accompany all real estate transfers of properties with oceanfront, sound or creek frontage in coastal counties.
2.	**Rising Sea Levels**	• Loss of barrier islands, property damage, serious disruption to local and regional economies and tourism. • Inundation of low-lying coastal land and structures, loss of shallow near-shore habitat for fisheries in early life stages and loss of wetlands due to hardening of estuarine shoreline, saltwater intrusion to	• Retreat from low-lying lands, prohibit or reduce hardening of estuarine shorelines, limit construction in 100-year floodplain, and significantly increase estuarine buffers and oceanfront setbacks. • Enact law that authorizes the state to secure a rolling property easement as sea level rises. • Require that local government coastal land use plans include a strategic plan for responding to sea level rise.	• The General Assembly should create a Coastal Adaptation Program. The program should be funded through a surcharge on the NC Beach Plan (insurance pool). Funds should be targeted for the purchase of conservation easements on low-lying coastal lands; for cost share incentive with land

	Issue	Potential Effects or Impacts	All Possible Responses	Preliminary Recommendation
		groundwater and aquifers.	• Place the highest priority for permitting estuarine shoreline stabilization on techniques that protect fisheries habitat. • Establish a series of permanent monitoring stations to measure the absolute changes in sea level rise in coastal NC and characterize the dynamics of estuarine storm surges, astronomical and wide tides and water flow. • Inventory and map the estuarine and ocean shoreline and its bathymetry, sediments, and vegetation.	owners the construction of ecologically beneficial erosion control structures on estuarine shorelines; and for research to provide an assessment of the physical and ecological properties of the estuarine shoreline and the potential cumulative impacts.
			• Develop policies concerning controversial economic and resource maintenance issues for the NC coastal zone in the face of potential and direct consequences of climate change. • Define a set of short-term, mid-term and long-term environmental change targets concerning what mitigation measures should be required if specific effects of climate change reach projected levels. • Develop and implement an environmental scorecard that would track ecosystem change.	

	Issue	Potential Effects or Impacts	All Possible Responses	Preliminary Recommendation
B. Agriculture and Forestry				
3.	**Forestry**	• Warmer climate may change the types of tree species that can be grown economically.	• Compile and evaluate existing research on the effects of a warmer climate on forest ecosystems and commercially grown tree species and potential impacts on the forest products and Christmas tree industries. • Conduct research as needed to identify the potential effects of a warmer climate on forest ecosystems and potential impacts on the forest products and Christmas tree industries. • Search for alternate economic Ventures to replace the Christmas tree industry or other fir/pine trees that do well in hotter climates. Sponsor gene manipulation work to adapt existing trees.	

	Issue	Potential Effects or Impacts	All Possible Responses	Preliminary Recommendation
4.	**Agriculture**	• Warmer climate may change the types of crops that can be grown economically.	• Compile and evaluate existing research on the effects of a warmer climate on crop species to assess potential effects of a warmer climate on the agricultural industry. • Conduct research as needed to identify the potential effects of a warmer climate on the agricultural industry. • Search for alternate crops that respond well to hotter temperatures, consider growing conditions in controlled environments. Sponsor gene manipulation work to adapt existing crops.	
5.	**Pest Lifecycle Changes**	• Pests may become more virulent as temperatures rise and their habitat ranges increase. • Crops may suffer from new, foreign pests and treating them will be more challenging especially if there is no prior experience addressing their impacts.	• Research alternative methods for addressing new pests and management techniques. Develop anticipated pest problems based on problems elsewhere.	

	Issue	Potential Effects or Impacts	All Possible Responses	Preliminary Recommendation
C. Water Quality and Quantity				
6.	**Saltwater Intrusion into Aquifers**	• Loss of drinking water and industrial process water sources.	• Desalinization plants. • Use of new briny water for CO_2 sequestration. • Injection of fresh water into aquifers.	
7.	**Drought Risk**	• Limits economic growth, reduces agricultural yields, reduces aquatic habitat.	• Water reuse of wastewater from tertiary treatment plants, use of cisterns and rain barrels, water conservation techniques.	
8.	**Flooding**	• Stronger storms will bring flooding causing displacement of communities through loss of homes, and potentially severe impacts on agricultural operations and managed forest lands.	• Collect flood waters to replace water supply capacity lost from aquifers. • Develop added flood protection schemes, including impoundments, zoning, changes, and the addition of public right of ways.	

	Issue	Potential Effects or Impacts	All Possible Responses	Preliminary Recommendation
9.	**Storm Water Runoff**	• Flooding, water quality degradation, scouring of stream beds and banks, loss of fisheries habitat.	• Manage storm water onsite, utilize low-impact development techniques, or prohibit construction in the 100-year floodplain. • State law that requires development to capture and treat storm water onsite from the 10-year 24-hour storm. • Create a low-impact development unit within the Division of Water Quality to assist developers to design development projects that utilizes low-impact development techniques to protect water quality and prevent flooding by managing storm water onsite. • Prohibit development or redevelopment within the 100-year floodplain.	
D. Air Quality Issues				
10.	**Fine Particulate Concentrations**	• Premature death, lung disease, aggravation of respiratory and cardiovascular disease, decreased lung function, asthma attacks, and certain cardiovascular problems such as heart attacks and irregular heart beat.	• Determine air quality strategies necessary to compensate for increased emissions associated with increasing temperatures.	

	Issue	Potential Effects or Impacts	All Possible Responses	Preliminary Recommendation
11.	**Ground Level Ozone Increases**	• Damage and irritation to lung tissue. • Reduced lung capacity. • Aggravated asthma. • Increased susceptibility to respiratory illnesses like pneumonia and bronchitis. • Ozone in the lower layers of the atmosphere contributes to global warming. • Damage to plants. • Oxidation of building materials.	• Determine air quality strategies necessary to compensate for increased emissions associated with increasing temperatures.	
12.	**Visibility Impacts**	• Degradation of scenic vistas at national parks and wilderness areas.	• Determine air quality strategies necessary to compensate for increased emissions associated with increasing temperatures.	
13.	**Increase in Pollen/Mold Spores**	• Cardiovascular disease, respiratory disorders such as asthma, emphysema and chronic bronchitis, and allergy problems.	• Public awareness measures. • Public awareness measures.	

	Issue	Potential Effects or Impacts	All Possible Responses	Preliminary Recommendation
E. Public Health				
14.	**Insect, Tick and Rodent Borne Diseases**	• Increased risk of diseases not previously seen in the state or increases in existing vector borne diseases.	• Study how potential climate changes can create the environment for previously unseen or rare vector borne diseases to exist (e.g, malaria and dengue fever.). • Strengthen state and local public health infrastructures to include improved disease surveillance, prevention, and response capabilities.	
15.	**Heat-related Illness/Death**	• Increase in heat related deaths and illnesses to sensitive populations during extreme heat waves.	• Study impact of extended heat waves on sensitive populations. • Develop possible responses for sensitive populations to minimize the impact of severe and prolonged heat waves. • Develop a strategy for providing and communicating heat wave behavioral adaptations such as air conditioning availability and increased fluid intake.	
16.	**Water and Food-Borne Illnesses**	• Increased potential for water and food borne diseases due to extreme climate events.	• Changes in building codes and zoning to prevent storm and flood damage. • Design of sewer and storm water systems to prevent fresh water contamination. • Increase public health surveillance systems to detect and quickly contain disease outbreaks.	

	Issue	Potential Effects or Impacts	All Possible Responses	Preliminary Recommendation
F. Economic Issues				
17.	**Loss of Ski Area Viability**	• Decrease in the number of ski-able areas and decrease in number of ski-able days in the year as temperatures rise.	• Increase tourism advertising for non-ski-related activities in spring, summer, and fall months (e.g., mountain biking, hiking, and adventure racing). Develop infrastructure for multi-use, nice-weather mountain exploration (e.g., gondolas).	
18.	**Loss of Homes and Community Displacement**	• Ongoing sea-level rise and stronger storms could eventually lead to the loss of inhabitable communities on the coast. Homeowners with beach front properties and other areas prone to flood (including low-income communities) may be required to relocate – costing the towns, counties, state and federal government.	• Survey vulnerable current inhabited areas, develop relocation plans and contingency measures in the event of emergencies. Be clear on economic support for covering relocation costs comes from.	
19.	**Loss of Fishing Tourism**	• As waters warm in the mountains, fishing for trout decreases as a tourism opportunity.	• Redirect tourism emphasis from fishing to non-climate impacted tourism industries, encourage other forms of fishing for species that are more heat-tolerant.	
G. Other Issues				

	Issue	Potential Effects or Impacts	All Possible Responses	Preliminary Recommendation
20.	**Wildlife and Fishing Impacts**	• Losses to commercial fishing from strong tropical storms. • Disruption of normal fishing cycles, loss of habitat. • Warmer fresh water decreases viable habitat for cold-water fish species like trout.	• Consider emergency preparedness to stock creeks with fish post-storm and flooding instances. • Prepare public education materials to increase awareness of species disturbance and lost habitat.	
21.	**Insurance Industry**	• The potential effects or impacts associated with many of the issues previously listed may increase insurance rates or may cause cancellation of insurance policies and other related issues.	• Insurance companies are evaluating the effects or impacts of climate change on the insurance lines they offer and are evaluating how to manage risk associated with losses believed to be cause by climate change.	

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Residential, Commercial, and Industrial (RCI) Technical Work Group Catalog of State Climate Mitigation Options

Prepared for the RCI Technical Working Group (TWG) Call #4, June 29, 2006, 10:30 AM

Key to Rankings of Options in the Table that Follows:

Potential Emission Reductions 1/	Potential Cost or Cost Savings 1/ 2/
High (H): At least 1 Million Metric Tons (MMT) carbon dioxide equivalent (CO_2e) per year by 2020 (~1% of current NC emissions)	**High (H)**: $50 per Metric Ton CO_2e ($MTCO_2e$) or above
Medium (M): From 0.1 to 1 MMT CO_2e per year by 2020	**Medium (M):** $5-50/$MTCO_2e$
Low (L): Less than 0.1 MMT CO_2e per year by 2020, or 1 MMT CO_2e by 2050	**Low (L):** Less than $5/$MTCO_2e$
Uncertain (U): Not able to estimate at this time	**Uncertain (U):** Not able to estimate at this time

1/ Several measures may overlap in terms of emissions reductions and/or cost impacts. Estimates assume measures would be implemented independently from other measures.
2/ Costs are denoted by a positive number. Cost savings (i.e., "negative costs") are denoted by a negative number.

NOTE: This version of the "Options Catalog" includes in yellow highlighted text RCI suggestions from TWG following made during and following the RCI TWG Call #3 (6/6/2006). Also included are rough, initial notations on potential emissions reduction and potential cost or net cost savings compiled by Center for Climate Change staff. These estimates are intended to give TWG members an approximate idea of the savings and costs that can be expected from policy options, but are NOT intended as definitive categorizations, and are open to re-estimation as needed.

Definition of "Priorities for Analysis":

- **High:** High priority options will be analyzed first.
- **Medium:** Medium priority options will be analyzed next, time and resources permitting.
- **Low**: Low priority options will be analyzed last, time and resources permitting.

*** Options marked with an asterisk (*) indicate options that are at least partially "base case" policies, i.e., that have been considered or undertaken at some level in North Carolina.**

**** Options marked with a double asterisk (**) indicate options that are included as recommendations in the September 1, 2005 NC DENR Report under the Clean Smokestacks Act of 2002.**

***** Options marked with a triple asterisk (***) indicate options that are included in or consistent with recommendations by the North Carolina Legislative Commission on Global Climate Change**

TWG MEMBERS PLEASE NOTE: This version of the Catalog, with the old, longer listing of options, is being provided to reflect suggested changes to the catalog offered by members during the TWG meeting of 6/6/06. For TWG Meeting #5 and subsequent meetings, we will be moving to a consolidated list of options, a draft of which was circulated prior to TWG Meeting #4. The text included in "long" version of the Catalog will, however, remain available for inclusion in both the consolidated list of options and, for those options named as "high priority" options by the TWG, in "policy descriptions" (to be developed by the TWG in the coming months) that elaborate and provide a basis for estimates of costs and benefits of each of the high priority options.

Option No.	GHG Reduction Policy Option	Priority for Analysis	Potential GHG Emissions Reduction	Potential Cost or Cost Savings	Additional Impacts, Feasibility Considerations	Notes
RCI-1	**Energy Efficiency Programs, Funds, and Goals**					
1.1	Demand Side Management (DSM) Programs for electricity, natural gas, propane, fuel oil* ***		High	Cost Savings - High Cost	Co-benefits could include transmission/ distribution system costs reduction. Significant potential overlap with many other options. Implementation should include utility incentives to provide substantial programs, and also substantial incentives for consumers to participate. TWG members noted that that energy-efficiency programs should be "cost-justified".	Electric Utilities providing DSM programs include: Progress Energy, Dominion Power, Duke Energy. Programs mostly information only, with a few financing programs[1]. http://www.seea.us/PDFs/SEEADSM.pdf Gas utilities and other fuel provider organizations include Piedmont Natural Gas, Scana - Public Service Company North Carolina (PSCNC), North Carolina Propane Gas Association, North Carolina Petroleum Marketers Association, and Carolina Fuel Institute TWG members noted that costs and performance vary substantially between measures within this option, that some options may present low capital costs and higher operating costs (or vice versa), and that there is uncertainty about the costs and savings for some options. Should include LED, other efficient lighting

[1] Other ongoing programs in North Carolina that are relevant to this policy option include the Industrial Extension Service (IES) at NCSU, energy and water efficiency programs at the Division of Pollution Prevention and Environmental Assistance (DPPEA), Western Waste Reduction Partners (WRP) and other similar programs. The North Carolina State Energy Office also offers a number of programs in many sectors.

Option No.	GHG Reduction Policy Option	Priority for Analysis	Potential GHG Emissions Reduction	Potential Cost or Cost Savings	Additional Impacts, Feasibility Considerations	Notes
RCI-1	**Energy Efficiency Programs, Funds, and Goals (continued)**					
1.2	Expand Energy Efficiency Funds (e.g. Public Benefit Funds) administered by State agency, utility, or 3rd party (e.g. Advanced Energy Corporation)** ***		High	Cost Savings/ Low Cost	[As above] Should provide programs with substantial incentives for consumer to participate	CSA recommendation LT-5, *Develop a Public Benefits Fund* NCUC is presently investigating several issues involving DSM and Energy Efficiency in the current Integrated Resource Planning Docket No. E-100, Sub 103. This investigation includes Public Benefit Funds. Costs for this policy are also uncertain, depending on measures included. Separating into private-,public-sector measures suggested May wish to consider breaking this option into public and private components

Option No.	GHG Reduction Policy Option	Priority for Analysis	Potential GHG Emissions Reduction	Potential Cost or Cost Savings	Additional Impacts, Feasibility Considerations	Notes
RCI-1	**Energy Efficiency Programs, Funds, and Goals (continued)**					
1.3	Energy Efficiency Requirements (e.g. Utility Savings Goals or Energy Portfolio Standards) **		High	Cost Savings/ Low Cost	[As above]	CSA recommendation LT-4, *Continue to Establish and Expand Efforts to Formulate and Adopt Renewable Portfolio Standards and Environmental Portfolio Standards* May wish to tie to or repeat current NC legislation proposals (Urlaub/Kalland) Costs for this policy are also uncertain, depending on measures included. The North Carolina Utilities Commission has a study on the costs and benefits of an RPS underway May wish to consider breaking this option into public and private components
1.4	Market transformation and technology development programs		High	Cost Savings/ Low Cost		Could include market transformation for improved electric motors and drives, heat pumps Could include industry/ government partnerships May also wish to include mobile homes under this option

Option No.	GHG Reduction Policy Option	Priority for Analysis	Potential GHG Emissions Reduction	Potential Cost or Cost Savings	Additional Impacts, Feasibility Considerations	Notes
RCI-2	**Appliance Standards**					
2.1	Development of State-level Appliance Efficiency Standards*		Low-High	Cost Savings/ Low Cost	Feasibility enhanced by ongoing effort in nearby states	State Energy Plan (SEP) recommends ENERGY STAR from 2008 on
2.2	State Voices Support for Adoption of More Stringent Federal-level Appliance Efficiency Standards		Low-High	Cost Savings/ Low Cost	Potential overlap with previous option	One or both of 2.1 and 2.2 should be defined broadly enough to include, for example, commercial sector, and IT equipment May wish to consider design for recycling of materials in appliances as part of standards

Option No.	GHG Reduction Policy Option	Priority for Analysis	Potential GHG Emissions Reduction	Potential Cost or Cost Savings	Additional Impacts, Feasibility Considerations	Notes
RCI-3	**Buildings**					
3.1	Improved Building Codes, including improved enforcement of codes* See also 3.4 and 3.15		High	Cost Savings/ Low Cost	Potential to also yield water savings, comfort/air quality improvements.	NC has building energy codes modeled on IEC 2000 for residential and commercial and enforced by Building Code Council, SEP R-4 recommends reviewing compliance and potential improvement. Analyses have been undertaken by Jeff Tiller at ASU Will want to make more specific as TWG work continues Building codes are enforced by the Building Code Council and the North Carolina Department of Insurance It may be useful to separate public- and private-sector components of this option May wish to include Mobile Home Manufactured Industry in discussion of this issue Could include X%/yr improvement mandate A TWG member suggest that building codes include a requirement that existing homes and commercial buildings at resale are upgraded to meet an energy efficiency standard, and financing programs be provided to help with the costs of those upgrades.

Option No.	GHG Reduction Policy Option	Priority for Analysis	Potential GHG Emissions Reduction	Potential Cost or Cost Savings	Additional Impacts, Feasibility Considerations	Notes
RCI-3	**Buildings (continued)**					
3.2	Promotion and Incentives for Improved Design and Construction (e.g. LEED[2], green buildings, Healthy Built Homes, ENERGY STAR Homes) * *** See also section 6.1 Incentives for Technologies and 6.5 White roofs and Landscaping Could also include the promotion of active and passive solar building technologies LEED Certification for State and Local Government Buildings and Universities, and Other Buildings Constructed with State Funds LEED buildings should include minimum # of points in energy efficiency section (or possibly an optimized energy efficiency section). The Energy Independence Act, S2051 filed May 2006, requires facility projects that receive state funding to reduce energy purchases by 20% by 2015.		Medium/ High	Cost Savings/ Low Cost	Potential overlap with previous option [co-benefits as above]	NC Green Building Technology database provides searchable database on case studies S2001, H1272 required state government to review the use of High Performance Building guidelines in 7 buildings. Examples of existing programs: NC Healthy Built Homes Healthy Building Resource Center Environments for Living[3] SEP recommends : a. ENERGY STAR home requirements by county. b. energy efficient mortgages. c. develop further programs to support privately funded projects d. Require high performance building standards for permits to build privately funded school projects A TWG member recommends support of an energy use reduction mandate for all publicly owned buildings, 40% new and 10% existing by {set date}. It may be useful to separate public- and private-sector components of this option Apply to existing buildings as well as new

[2] LEED = Leadership in Energy and Environmental Design, a national building certification program.

Option No.	GHG Reduction Policy Option	Priority for Analysis	Potential GHG Emissions Reduction	Potential Cost or Cost Savings	Additional Impacts, Feasibility Considerations	Notes
RCI-3	**Buildings (continued)**					
3.3	Training and Education for Builders and Contractors (e.g. HVAC[4] sizing, duct sealing, energy analysis program, C&D waste recycling, renewable energy system installation, water distribution systems) *		Medium	Cost Savings/ Low Cost	[As above]	Advanced Energy Corporation and NC Solar Center, and others have ongoing programs in this and similar areas Option could include introduction of related skills in the Trade School and Community College Curricula (see 3.13)
3.4	Training of Building Code and other Officials in Energy Code Enforcement* See also 3.1 and 3.15		Medium	Cost Savings/ Low Cost		Recommended in State Energy Plan
3.5	Building Commissioning and Recommissioning, including Energy Tracking and Benchmarking		Medium	Cost Savings/ Low Cost		Could include provision for performance testing as an element of building commissioning and recommissioning Recommissioning important for rehabilitated older buildings[5]
3.6	Energy Management Training/Training of Building Operators*		Medium	Cost Savings/ Low Cost		SEP recommends training programs for state building operators and for private building operators

[3] In addition to those listed, groups offering programs and other services related to building energy efficiency and related programs include CERT at NCA&T, Appalachian State, Southern Research Institute, RTI, and others.
[4] HVAC = Heating, Ventilation, and Air Conditioning
[5] This and several other recommended related to RCI policies are included in the document Commission on Smart Growth, Growth Management and Development: Findings and Recommendations, dated Fall, 2001, and available as http://www.ncsmartgrowth.org/archive/sg_commission/sgcrpt.pdf. This document (and the process that generated it) was referenced by attendees at the 5/23 CAPAG meeting.

Option No.	GHG Reduction Policy Option	Priority for Analysis	Potential GHG Emissions Reduction	Potential Cost or Cost Savings	Additional Impacts, Feasibility Considerations	Notes
RCI-3	**Buildings (continued)**					
3.7	Increased Use of Blended Cement (substituting fly ash or other pozzolans for clinker reduces CO_2 emissions)		Low/ Medium	Cost Savings/ Low Cost	May provide modest avoided waste disposal co-benefit, depending on standard practice	(TWG member suggests should be in Section 6). This suggestion discussed during call#2; TWG decided to keep option in Section 3. Impact of fly ash as clinker substitute being studied in state.
3.8	Reduction of Emissions from Diesel Engines Used in New Construction Developments		Low	Low Cost		For example, require all new diesel engines for construction equipment meet low emission standards within 5 years
3.9	Support for growth and health of the residential building performance specialist industry.		Uncertain	Cost Savings/ Low Cost		
3.10	Continuing Education for building Design Professionals, including architects, engineers, developers, contractors, urban planners, and realtors		Uncertain	Cost Savings/ Low Cost		
3.11	Promote work scheduling and telecommuting as means of reducing building energy consumption		Uncertain	Uncertain		For example, can moving to 4 10-hour workdays from 5 8-hour shifts save energy? How can telecommuting affect building use efficiency? It was noted that even reducing occupancy of a commercial building by half might not change building energy much. (Would need co-ordination with Transport TWG)
3.12	Promotion of the use of locally created and available building materials		Uncertain	Uncertain		

Option No.	GHG Reduction Policy Option	Priority for Analysis	Potential GHG Emissions Reduction	Potential Cost or Cost Savings	Additional Impacts, Feasibility Considerations	Notes
RCI-3	**Buildings (continued)**					
3.13	Energy efficiency and related education introduced at community colleges and trade schools ***		Uncertain	Cost Savings/ Low Cost		Suggested during call#2
3.14	Clearinghouse for information on and access to software tools to calculate impact of energy efficiency and solar technologies for buildings ***		Uncertain	Cost Savings/ Low Cost		Suggested during call#2, Advanced Energy Corporation is currently reviewing nine calculators. Availability of tools could be widened.
3.15	Improved enforcement of building codes See also 3.1 and 3.4		Uncertain	Cost Savings/ Low Cost		Suggested by TWG member following call#2
3.16	Add Photovoltaic Panels on New Commercial Buildings and Many New Homes; Add Solar Hot Water Heaters on Homes and Other Buildings		High	Medium – High Cost		Suggested by CAPAG member, part of "Vision of NC Future". (not clear if intent was as a voluntary or mandatory policy) [6]
3.17	Cap on Consumption of Energy per Unit Area of Floorspace for New (?) Buildings		High	Cost Savings – Medium Cost		Suggested at CAPAG meeting. Would include reduction of cap figure over time, ensuring continuous improvement
3.18	Solar Hybrid Lighting (using light guides to bring daylight into building interiors)		Uncertain	Uncertain		Suggested at CAPAG meeting.
3.19	Increase Flexibility within Building Codes for Use of Non-conventional Energy-efficient Building Materials		Uncertain	Uncertain		Suggested at CAPAG meeting; straw bale construction an example.

[6] At the 5/23CAPAG meeting, the Environments for Living program (http://www.eflhome.com/) was noted as an example, with builders having built 80,000 homes in the South and Southwest under the program in the last five years. Also, it was noted that solar water heating is included in the NC Green Power Program.

Option No.	GHG Reduction Policy Option	Priority for Analysis	Potential GHG Emissions Reduction	Potential Cost or Cost Savings	Additional Impacts, Feasibility Considerations	Notes
RCI-3	**Buildings (continued)**					
3.20	Promote SmartGrowth designs that also reduce energy and water consumption in buildings		Uncertain	Uncertain		Higher building density and site orientation will influence energy consumption in the RCI sectors and in other sectors (such as transport). Increasing density in downtowns of existing communities can reduce energy and water losses that occur in transmission to new remote sub-divisions[7].
3.21 (NEW) Proposed new option	Inventory of materials and equipment in current building stock					To provide information on the potential for energy efficiency in NC buildings
RCI-4	**Education and Outreach**					
4.1	Consumer education programs** *** (Probable overlap with Cross-Cutting TWG)		Uncertain	Cost Savings/ Low Cost		Potential contribution difficult to estimate CSA Recommendation A-7: Public Education on Climate Change Continued funding to meet the expanding role of State Energy Office as a key consumer information outlet. Emphasize provision of resources directing consumers to information and technologies for energy-efficiency and climate impacts reduction

[7] Commission on Smart Growth (2001—see earlier footnote for full reference) recommends developing "smart growth management tools that encourage … compact neighborhoods and more intensive use of land". The document also recommends encouraging development of downtown areas. This option will likely overlap heavily with options in the Transportation and Land Use TWG.

Option No.	GHG Reduction Policy Option	Priority for Analysis	Potential GHG Emissions Reduction	Potential Cost or Cost Savings	Additional Impacts, Feasibility Considerations	Notes
4.2	Introduce in School Curriculum *** (Probable overlap with Cross-Cutting TWG)		Uncertain	Cost Savings/ Low Cost		[As above] NC Air Aware provides info for teachers, focus on ozone. http://daq.state.nc.us/airaware/
RCI-5	**Pricing and Purchasing**					
5.1	Green Power Purchasing*		Medium/ High	Low - High	(Consider pricing of green power so that it is less expensive to consumers than conventional power, reflecting its climate benefits) In some cases green power has been more resistant to cost swings than conventional power	The North Carolina Green Power Program has been in place for approximately 3 years. It solicits voluntary contributions from utility customers for use in subsidizing green power purchases in North Carolina (TWG member input) SEP recommends state commit to state-use purchases of 25% growing to 100% (10% as near-term goal for State—next 3 years?) Interaction with RPS option[8]. Consider adding feature to emphasize purchase of green power generated in NC
5.2	Bulk Purchasing Programs for Energy Efficiency or other Equipment (Public or Private sector)		Low - High	Cost Savings/ Low Cost		May interact with utility programs. May wish to use in combination with standards for appliance purchases by state agencies.

[8] Will require development of Green Power supplies, thus will need to be coordinated with Energy Supply group policy options.

Option No.	GHG Reduction Policy Option	Priority for Analysis	Potential GHG Emissions Reduction	Potential Cost or Cost Savings	Additional Impacts, Feasibility Considerations	Notes
RCI-5	**Pricing and Purchasing (continued)**					
5.3	Review net-metering policies (for example, for electricity consumers who install on-site combined heat and power or, distributed generation fueled with renewable or fossil fuels) *		Low / Medium	Cost Savings/ Low Cost		Policy on net metering has been established by the NCUC, and corresponding tariffs approved, in Docket No. E-100, Sub 83. The establishment of Small Generator Interconnection Standards in Docket No. E-100, Sub 101 is designed to streamline the process for customers seeking to install net metering applications, as well as other small renewable energy generation applications.(TWG member input) Review could consider the impact of NO_x and power factor requirements on net-metering and availability of information for small customers.

Option No.	GHG Reduction Policy Option	Priority for Analysis	Potential GHG Emissions Reduction	Potential Cost or Cost Savings	Additional Impacts, Feasibility Considerations	Notes
RCI-5	**Pricing and Purchasing (continued)**					
5.4 (OLD)	~~Time of Use Rates (including, for example, rates that vary by time of day so as to provide consumers with signals to reduce peak demand, or to offer incentives for on-peak distributed generation)*~~		~~Low / Medium~~	~~Cost Savings/ Low Cost~~	~~Significant utility system co-benefits~~	~~Time-of-use rates and real time rates for electric customers are currently in place. Time of use rates have been in effect for at least the last twenty years, and, with the exception of Dominion NC Power, real time rates have been available for at least the last ten years.(TWG member input)~~ Option eliminated since it is well-established in NC
5.4	Performance-based Contracting for finding of energy efficiency improvements		Medium – High?	Cost Savings/ Low Cost?		Capital costs paid back through energy savings
5.5	Utility Rate Reform		Uncertain	Uncertain		At CAPAG Meeting on 5/23, it was suggested that there is a need to look harder at rate issues in NC, including decoupling (of utility revenues from sales) and rate design, with a specific focus on the impacts of rate design on greenhouse gas emissions

Option No.	GHG Reduction Policy Option	Priority for Analysis	Potential GHG Emissions Reduction	Potential Cost or Cost Savings	Additional Impacts, Feasibility Considerations	Notes
RCI-6	**Technology-Specific Policies**					
6.1	Incentives for Renewable Energy Applications *** (Solar roofs, water heaters, etc.), including tax incentives		High	Cost savings/ High	Programs could help to lower capital and installation costs	Incentives could reduce first cost to a specific payback level; could be coupled with requirements for new buildings[9]
6.2	Clean Combined Heat and Power *		High	Cost Savings - Medium Cost	Cost dependent on price of natural gas; interconnection an issue; utility system co-benefits.	SEP recommendation Consider use of waste heat from new electricity generation units to substitute for fossil-fueled heat in the RCI sectors. In some cases of industrial CHP, it may be necessary to assess the impact of CHP presence on given distribution circuit New and existing technologies allow CHP to be used in residential, commercial sectors as well, so these sectors should be included[10]
~~6.3 -~~	~~Promotion and Tax or Other Incentives (e.g. Energy Star, credits for solar hot water)~~		~~High~~	~~Cost Savings/ Low Cost~~	~~Interaction with appliance standards, utility programs.~~	Now included in 6.1

[9] Specific implementation measures mentioned as possible for this policy include tax credits, low/no interest loans, and similar financial incentives to business, industries and commercial firms to upgrade their equipment (including manufacturing and pollution control equipment) to more energy efficient technologies. The latter approach is especially important for small manufacturers, and could just be access to mico-loans.

[10] Examples cited at the 5/23 CAPAG meeting include stacks of newly-developed ½ watt fuel cells, 1 kW residential CHP providing hot water, and microturbines for residential and small commercial applications.

Option No.	GHG Reduction Policy Option	Priority for Analysis	Potential GHG Emissions Reduction	Potential Cost or Cost Savings	Additional Impacts, Feasibility Considerations	Notes
RCI-6	**Technology-Specific Policies (continued)**					
6.3	Appliance Recycling/Pick-Up Programs*		Low	Cost Savings/ Low Cost	Long-term impact uncertain	SEP recommends appliance-swapping Consider as an implementation strategy providing waiver of dumping and disposal fees where appliances are replaced with Energy Star appliances Program exists already in NC to dispose of a refrigerator for free. This program would target retiring of working but inefficient appliances.
6.4	White Roofs, Rooftop Gardens (Green Rooftops), and Landscaping (including Shade Tree Programs)*		Medium/ High	Cost Savings/ Low Cost	Results likely to vary substantially with design	SEP recommends developing and implementing further programs to promote 'Cool Cities' and white roof Programs. May wish to include a requirement for government buildings to have white roofs. Encourage/promote regenerative, sustainable design

Option No.	GHG Reduction Policy Option	Priority for Analysis	Potential GHG Emissions Reduction	Potential Cost or Cost Savings	Additional Impacts, Feasibility Considerations	Notes
RCI-6	**Technology-Specific Policies (continued)**					
6.5	Promotion of distributed generation by renewables and clean fossil fuels (including microturbines, internal combustion engines, and fuel cells***)		Medium/ High	Uncertain	Cost savings and decreased impacts of transmission and distribution	SEP recommends the Department of Commerce and the State Energy Office 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, biofuels, and fuel cells. Renewables options can go beyond use on/in buildings-only (e.g., by NC DOT)
6.6	Capture and use process heat from industrial and commercial operations		Uncertain	Uncertain		Suggested during call#2
6.7	Solar-powered (absorption) Air Conditioning for residential and Commercial Applications		Uncertain	Uncertain		Suggested during CAPAG Meeting #2
6.8	Promotion of Ground-source Heat Pumps for Residential and Commercial Heating and Cooling		Medium	Cost Savings – Medium Cost		Suggested during CAPAG Meeting #2

Option No.	GHG Reduction Policy Option	Priority for Analysis	Potential GHG Emissions Reduction	Potential Cost or Cost Savings	Additional Impacts, Feasibility Considerations	Notes
RCI-6	**Technology-Specific Policies (continued)**					
6.9	Focus on specific end-uses/technologies: window AC units, lighting, water heating, plug loads, networked PC management, power supplies, motors, pumps, boilers, etc. Consumer products programs, may include incentives, retailer training, marketing and promotion, education, etc *, **		(By option, range from Low to High)	Cost Savings/ Low Cost	Interaction with appliance standards, utility programs.	In 1980 the North Carolina Utility Commission (NCUC) established a systems benefit charge, creating a non-profit corporate to administer the funds with the charter "to encourage energy efficient economic development in North Carolina." The non-profit Advanced Energy operates programs for subsidized and market-rate home construction, and provides energy efficiency assistance to North Carolina industry. http://www.advancedenergy.org/ State Energy Office is involved in federal Industries of the Future. CSA recommendation A-5: *Promote and Support Efforts to Establish North Carolina as a World Leader in GHG, Non-Carbon Fuels and Energy Efficiency Technologies* SEP recommends further incentives for high efficiency motors

Option No.	GHG Reduction Policy Option	Priority for Analysis	Potential GHG Emissions Reduction	Potential Cost or Cost Savings	Additional Impacts, Feasibility Considerations	Notes
RCI-7	**Non-Energy Emissions (HFCs, PFCs, SF_6, CO_2 Process Emissions[11]**					
7.1	Participation in Voluntary Industry-Government Partnerships Some TWG Members suggest that this be moved into another section?? SECTION 1?		Uncertain	Medium		For example, Climate Leaders, a USEPA program (see that "..encourages companies to develop long-term comprehensive climate change strategies and set [GHG] emissions reduction goals."[12] A state recognition and reward program can be an effective tool for emissions reduction. This policy could be part of the existing Environmental Stewardship Initiative (ESI, see www.p2pays.org/esi).
7.2	Process Changes/ Optimization (Improving manufacturing so as to require less energy and/or release less GHG process gases to the atmosphere)		Uncertain	Uncertain		Impact, cost likely highly process-specific There are a number of efforts in NC being coordinated by Industrial Extension programs[13]

[11] North Carolina has relatively few electronic component manufacturing facilities, which may limit the application of some of the policy options in this section. Implementation of many of these policy options could, as for option 6.1, include tax credits, low/no interest loans, and similar financial incentives to business, industries and commercial firms to upgrade their equipment (including manufacturing and pollution control equipment) to more energy efficient technologies.

[12] "Companies participating in Climate Leaders set a corporate-wide GHG reduction goal and inventory their emissions to measure progress". See http://yosemite.epa.gov/oar/globalwarming.nsf/content/ActionsNationalPartnerships.html. Also, note that this policy option, as with others in this section, is not designed to include energy efficiency for industries, which is included in other options.

[13] In addition, technical assistance on pollution prevention and manufacturing efficiencies is provided by DPPEA, WRP and others.

Option No.	GHG Reduction Policy Option	Priority for Analysis	Potential GHG Emissions Reduction	Potential Cost or Cost Savings	Additional Impacts, Feasibility Considerations	Notes
RCI-7	**Non-Energy Emissions (HFCs, PFCs, SF_6, CO_2 Process Emissions (continued)**					
7.3	Leak Reduction /Capture, Recovery and Recycling of Process Gases (gases used in industrial processes)		Medium	Uncertain		For example, solvents used in electronics industry, recovery of refrigerants, reduction of leaks in refrigeration equipment
7.4	Use of Alternative Gases (other HFCs, hydrocarbon coolants/refrigerants, foam blowing agents, etc.)		Medium/ High	Low/ Medium		For example, use of lower Global Warming Potential gases in specific applications, such as hydrocarbons in place of HFCs in commercial refrigeration Note that some of these changes may affect energy use as well
7.5	~~Cement Industry: Use of Alternative Fuels~~					Option removed since no cement plants in NC
RCI-8	**GHG Emissions-Specific Goals and Policies**					
8.1	Support for switching to less carbon-intensive energy resources (coal and oil to natural gas or biomass, electricity to solar water heating or space heating)		Medium/ High	Cost Savings/ Medium Cost	Cost dependent on relative fuel prices	Instances where fuel-switching is applicable (for example, electricity to natural gas for water heat, fossil fuels to biomass for space/process heat)
8.2	Industry-Specific Emissions Cap and Trade Programs		Medium/ High	Low/ Medium	Highly dependent on specification of trading systems	For example, participation of industrial consumers in a statewide or regional program of trading emissions allowances
8.3	Voluntary Emissions Targets for Industrial Operations		Uncertain	Uncertain		

Option No.	GHG Reduction Policy Option	Priority for Analysis	Potential GHG Emissions Reduction	Potential Cost or Cost Savings	Additional Impacts, Feasibility Considerations	Notes
RCI-8	**GHG Emissions-Specific Goals and Policies (continued)**					
8.4	Small-source Aggregation (to achieve reductions for groups of smaller-volume energy consumers)		Uncertain	Uncertain		For example, programs allowing the aggregation of commercial or residential consumers to set joint emissions targets, pursue
8.5	Negotiated Emissions or Energy Savings Agreements*		Uncertain	Uncertain		SEP recommendation. For example, agreements between government and industrial or other large GHG emitters to reduce emissions on a specific time-frame
RCI-9	**Other**					
9.1	Government Agency Requirements and Goals (including procurement)*		Uncertain	Cost Savings/ Low Cost		Potential overlap with other options SEP recommends state procurement of environmentally preferable products
9.2	Focus policies and programs for building energy efficiency on specific market segments: existing homes (weatherization), new construction, apartments, low income, etc. *,**		Medium/ High	Cost Savings/ Low Cost		Potential overlap with other options NC Weatherization Assistance Program, for low income earners SEP recommends extending weatherization

Option No.	GHG Reduction Policy Option	Priority for Analysis	Potential GHG Emissions Reduction	Potential Cost or Cost Savings	Additional Impacts, Feasibility Considerations	Notes
RCI-9	**Other (continued)**					
9.3	Reinvestment Fund* (providing financing for energy-efficiency and other GHG emissions-reduction efforts)		Uncertain	Cost Savings/ Low Cost	Would help to provide local employment and grow renewable energy use	Potential overlap with other options State Energy Office's has low-interest energy loan program, SEP recommends restructuring the underwriting provisions Use in part to create infrastructure to deliver energy-efficiency renewable technologies[14] Allow state agencies to keep net savings from energy efficiency actions or reinvest them
9.4	Municipal Energy Management (programs of energy-efficiency improvement coordinated at the municipal level)		Uncertain	Uncertain		Potential overlap with other options

[14] It was noted during the 5/23 CAPAG meeting that the NC Tax Credit for Renewable Technology Investment had "sunseted" (lapsed), and should be brought back (or replaced with a program with similar goals). It was also noted that the Reinvestment Fund could take the form of a Special fund for capital for businesses developing renewable energy sources, such as the Pennsylvania "Energy Harvest" program. It was suggested that other programs adopted by Pennsylvania may also be applicable to NC.

Option No.	GHG Reduction Policy Option	Priority for Analysis	Potential GHG Emissions Reduction	Potential Cost or Cost Savings	Additional Impacts, Feasibility Considerations	Notes
RCI-9	**Other (continued)**					
9.5	Focus on Small and Medium Enterprises (SMEs)* (Provide resources for small and medium businesses to evaluate and pursue energy efficiency/GHG emissions reduction activities)		Uncertain	Uncertain		Potential overlap with other options Industrial Assessment Center at NC State University provides energy conservation and cost reduction assessments to small to medium sized enterprises http://www.mae.ncsu.edu/Centers/IAC/ A TWG member suggests that this option be combined with options in RCI-1, along with options 9.6 and 9.7, below.[15]
9.6	Industrial ecology/ by-product synergy by including full circle of industrial by-product use within other industrial processes		Uncertain	Uncertain		For example, promote review and modification of industrial processes to encourage waste reduction, highly efficient use of materials and energy.

[15] This type of assistance is also currently provided by DPPEA and WRP, as well as the IES. In addition, the types of activities suggested in policy options 9.6 and 9.7 are also provided by DPPEA and WRP, and could be included in the demand side management recommendation as part of 1.1.

Option No.	GHG Reduction Policy Option	Priority for Analysis	Potential GHG Emissions Reduction	Potential Cost or Cost Savings	Additional Impacts, Feasibility Considerations	Notes
9.7	Industrial Audits* *** (For example, make available/encourage use of industrial audits to identify energy-efficiency, other GHG-emissions savings opportunities)		Medium/ High	Cost Savings/ Low Cost		Industrial Extension Services at NC State University provides surveys and audits of industrial operations to provide suggestions on cost savings from energy efficiency http://www.ies.ncsu.edu/energysurveys/[16] This option may require additional support for implementation of energy savings
9.8	Extend green campus initiatives to all university buildings*		Medium	Cost Savings/ Low Cost		SEP recommendation

[16] Waste Trader, an on-line waste exchange system, and Biomass Trader, a similar system for biomass, are joint projects between DPPEA and SEO that are relevant to option 9.7 (see www.p2pays.org for more information).

Option No.	GHG Reduction Policy Option	Priority for Analysis	Potential GHG Emissions Reduction	Potential Cost or Cost Savings	Additional Impacts, Feasibility Considerations	Notes
RCI-9	**Other (continued)**					
9.9	Energy benchmarking, measurement, and tracking programs for municipal and state buildings*		Medium	Cost Savings/ Low Cost		SEP recommendation
9.10	Integration with Regional Demand Response Initiatives/recommendations*		Medium	Cost Savings/ Low Cost		SEP recommendation
9.11	Water use reduction		Low/ Medium	Cost Savings/ Low Cost		TWG member input
9.12	Funding of Research and Development for Energy Efficiency, Renewable Energy, Other GHG Reduction Strategies***		Uncertain	Uncertain		Could include R&D contracts with private firms, grants and contracts with universities, Intramural R&D conducted at government labs, R&D contracts with private/public consortia
9.13	Direct or Indirect support for commercialization and production; Indirect support for development***					Could include patent protection, R&D tax credits, production subsidies or tax credits to firms bringing new technologies to market, tax credits or rebates for new technology buyers, government procurement, and demonstration projects

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Energy Supply (ES) Technical Work Group
Catalog of State Climate Mitigation Options

Prepared for the ES Technical Working Group (TWG) Call #3, June 1, 2006, 9:00-11:00 AM

Key to Rankings of Options in the Table that Follows:

Potential Emission Reductions 1/	Potential Cost or Cost Savings 1/ 2/
High (H): At least 1 Million Metric Tons (MMT) carbon dioxide equivalent (CO_2e) per year by 2020 (~1% of current NC emissions)	**High (H)**: $50 per Metric Ton CO_2e (MTCO_2e) or above
Medium (M): From 0.1 to 1 MMT CO_2e per year by 2020	**Medium (M):** $5-50/MT$CO_2$e
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1/ Several measures may overlap in terms of emissions reductions and/or cost impacts. Estimates assume measures would be implemented independently from other measures.
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Definition of "Priorities for Analysis":

- **High:** High priority options will be analyzed first.
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Notation of Options:

*** Options marked with an asterisk (*) indicate options that are at least partially "base case" policies, i.e., that have been considered or undertaken at some level in North Carolina.**

**** Options marked with a double asterisk (**) indicate options that are included as recommendations in the September 1, 2005 NC DENR Report under the Clean Smokestacks Act of 2002.**

Table 2 - Energy Supply (ES) - DRAFT

Option No.	Climate Mitigation Option	Priority for Analysis	Potential GHG Emissions Reduction	Potential Cost or Cost Savings	Ancillary Impacts, Feasibility Considerations	Notes
ES-1	**RENEWABLE ENERGY**					
1.1	Environmental Portfolio Standard (renewables and energy efficiency) with renewable energy credit trading**	Tentatively as "H"	H	L-H		Potentially attractive measure; let's keep this in consideration; need to learn more about ongoing commissioned study
1.2	NC Greenpower renewable resources program *		L	H		In effect since 2003; subscription rate currently quite low; voluntary customer demand-driven measure; effect on statewide GHG reductions appears to be negligible (about 0.1% of overall emissions); cost of measure is high (about $2/100 kWh). CAPACG: make sure to incorporate all elements of voided 1.3 into 1.2

Option No.	Climate Mitigation Option	Priority for Analysis	Potential GHG Emissions Reduction	Potential Cost or Cost Savings	Ancillary Impacts, Feasibility Considerations	Notes
~~1.3~~	~~State purchase of electricity through the NC Greenpower renewable resources program**~~		~~H~~	~~L-H~~		This measure has been eliminated as it overlaps with measure 1.2
1.4	Public Benefit Charge on electricity bills for funding efficiency activities**		H	H (savings)		Need to also consider tax credits or rebates for buyers of new, low-GHG emitting technologies
1.5	Renewable Energy Incentives (biomass, wind, solar, geothermal)*		Hi	Lo-Hi		CAPAG: address opening up of Ridge law, decrease barriers to wind, subsidies for wind development
1.6	Green Power Purchases and Marketing*		?	?		
1.7	Renewable energy development issues (zoning, siting, etc.)		?	?		
1.8	Research and Development (R&D) for renewable technologies		U	U		
1.9	Landfill Gas Recovery (see also Waste)		U	U		
1.10	Waste to Energy (see also Waste) **		Hi	L-H		
ES-2	**DISTRIBUTED GENERATION (DG)**					
2.1	Incentives for combined heat and power (CHP) and clean DG**		M-H	L		CAPAG: decrease regulatory barriers for local siting

Option No.	Climate Mitigation Option	Priority for Analysis	Potential GHG Emissions Reduction	Potential Cost or Cost Savings	Ancillary Impacts, Feasibility Considerations	Notes
2.2	Removing barriers to CHP and clean DG (including utility rate and interconnection barriers, financing, information, etc.)**		M-H	L		
2.3	Interconnection Rules for clean, distributed generation*,**		L	L		
2.4	Net Metering*,**		U	U		
2.5	Pricing strategies		?	?		
2.6	Portfolio Standards for Power Retailers		U	U		Envisioned to focus on distribution company standards
ES-3	**ADVANCED FOSSIL FUEL**					
3.1	Incentives for advanced coal, including IGCC and carbon capture and storage (CCS)		H	M/H		Need to consider advanced pulverized coal technologies (input from 11 April meeting). Also need to consider Production subsidies or tax credits to firms bringing new technologies to market
3.2	Incentives for CO2 pipelines for CCS		H	H		
3.3	Fuel Cell Development Incentives		U	U		
3.4	Combined H2/electricity production from fossil fuels with sequestration		Hi	H		

Option No.	Climate Mitigation Option	Priority for Analysis	Potential GHG Emissions Reduction	Potential Cost or Cost Savings	Ancillary Impacts, Feasibility Considerations	Notes
3.5	Research and Development (R&D) for advanced fossil fuel technologies.		U	U		Direct Government funding of R&D, though perhaps more appropriate at federal level, could affect NC through R&D contracts with private firms, R&D grants and contracts with NC universities, Intramural R&D conducted at government labs, R&D contracts with consortia (2 or more of the above), and R&D tax credits
3.6	Technology Standards for CO2 Sources		U	U		
ES-4	**NUCLEAR**					
4.1	New Nuclear Capacity and Licensing		L/H	M/H		CA[AG: address possibility of hydrogen production from nuclear electricity generation
4.2	Nuclear Plant Relicensing		Zero?			
4.3	Nuclear Plant Uprating		Zero?			
ES-5	**OTHER ELECTRICITY MEASURES**					
5.1	Efficiency Improvements and Repowering Existing Plants		U	U		CAPAG: will be important to capture fuel cycle impacts/benefits
5.2	Transmission System Upgrading		U	U		*5.2, 5.3, 5.4 could be combined*
5.3	Reduce Transmission and Distribution Line Loss					

Option No.	Climate Mitigation Option	Priority for Analysis	Potential GHG Emissions Reduction	Potential Cost or Cost Savings	Ancillary Impacts, Feasibility Considerations	Notes
5.4	Collaboration with other Southeast states		U	U		
ES-6	**EMISSIONS POLICIES**					
6.1	CO2 Tax		H	L/H		May need to be expanded to include emissions of other forms of carbon. CAPAG: require utilities to include a shadow price for CO2 in electric capacity planning
6.2	GHG Cap and Trade		H	L/H		
6.3	Generation Performance Standards		H	L/H		Will need to be clarified as to whether generation-only sources are envisioned
6.4	GHG Offset/mitigation requirements for new power plants		M/H	L/H		*Combine with 6.5*
6.5	GHG Offset/mitigation requirements for existing power plants		H	L/H		
6.6	Voluntary Utility CO2 Targets		L/M	L		
6.7	Rate restructuring					Added based on input from 11 April meeting
ES-7	**EDUCATION/AWARENESS**					
7.1	Brownfield Re-development		U	U		

Option No.	Climate Mitigation Option	Priority for Analysis	Potential GHG Emissions Reduction	Potential Cost or Cost Savings	Ancillary Impacts, Feasibility Considerations	Notes
7.2	Environmental (emissions) Disclosure		U	U		May need to be edited or expanded and linked with emissions policies explored
7.3	Public Education		U	U		CAPAG: address the need for a broad education program that includes lifecycle costs/emissions
7.4	Codification and transfer of knowledge		U	U		
7.5	Technology and/or industrial extension services		U	U		
ES-8	**INSITUTIONAL AND RD&D**					
8.1	Center for low-carbon technology development		U	U		
8.2	Demonstration projects for reducing GHGs		U	U		
8.3	Changes to PUC decision-making rules to consider carbon risk					

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Transportation and Land Use GHG Reduction Policy Options

Prepared for Technical Working Group (TWG) Call #3, June 8, 2006

Potential Emission Reductions 1/	Potential Cost or Cost Savings 1/ 2/
High (H): At least 1 Million Metric Tons (MMT) carbon dioxide equivalent (CO_2e) per year by 2020 (~1% of current NC emissions)	**High (H)**: $50 per Metric Ton CO_2e (MTCO_2e) or above
Medium (M): From 0.1 to 1 MMT CO_2e per year by 2020	**Medium (M):** $5-50/MT$CO_2$e
Low (L): Less than 0.1 MMT CO_2e per year by 2020, or 1 MMT CO2e by 2050	**Low (L):** Less than $5/MT$CO_2$e
Uncertain (U): Not able to estimate at this time	**Uncertain (U):** Not able to estimate at this time

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**** Options marked with a double asterisk (**) indicate options that are included as recommendations in the September 1, 2005 NC DENR Report under the Clean Smokestacks Act of 2002.**

Total number of options in this catalog: 72. Goal ~10 to recommend to CAPAG.

Option No.		GHG Reduction Policy Option	Priority for Analysis	Potential GHG Emissions Reduction	Potential Cost or Cost Savings	Ancillary Impacts, Feasibility Considerations	Notes
TLU	**1.**	**PASSENGER VEHICLE GHG EMISSION RATES**					
TLU	1.1	**Vehicle Technology**					
TLU	1.1.1	Tailpipe GHG Emission Standards **		**H**	**L**	**Opinions vary sharply on cost. Legal challenge pending.**	Assume California GHG standards (Pavley).
TLU	1.1.2	ZEV/LEV-2 Implementation **		**L**	**L/M**	**Primary benefit is CAA emissions reductions.**	
TLU	1.1.3	R&D on Low-GHG Vehicle Technology (e.g., fuel cell, low-weight vehicles, alt vehicles like Segway)		**L**	**U**	**Best coupled with federal dollars**	
TLU	1.1.4	Add-on Technologies (Low Friction Oil, Low-Rolling Resistance Tires)		**L**	**Savings/L**	**Most available now**	
TLU	1.2	**Vehicle Operation**					
TLU	1.2.1	Enforce Speed Limits		**L/M**	**L**		

Option No.		GHG Reduction Policy Option	Priority for Analysis	Potential GHG Emissions Reduction	Potential Cost or Cost Savings	Ancillary Impacts, Feasibility Considerations	Notes
TLU	1.2.2	Vehicle Maintenance, Driver Training		**L/M**	**U**		
TLU	1.2.3	Transportation System Management and Design, including ITS; limiting loops and bypasses; improving roadway planning		**M**	**L**		
TLU	1.2.4	Roadway materials use; concrete versus asphalt					
TLU	1.3	**Incentives & Disincentives**					
TLU	1.3.1	Procurement of Efficient Fleet Vehicles **		**L**	**L/M**		
TLU	1.3.2	Feebates (state-specific or regional) **		**L/M**	**Split; should be revenue neutral**	**CO2 benefits overlap substantially with Pavley**	
TLU	1.3.3	CO_2-based registration fees		**L/M**		**"; could accelerate turnover.**	
TLU	1.3.4	Tax Credits for Efficient Vehicles **		**L**			
TLU	1.3.5	Vehicle Scrappage		**L**	**L/M**		
TLU	**2.**	**LAND USE AND LOCATION EFFICIENCY**					
TLU	2.1	**General**					
TLU	2.1.1	Infill, Brownfield Re-development		**H**	**L**		
TLU	2.1.2	Transit-Oriented Development *		**H**	**L/M**		
TLU	2.1.3	Smart Growth Planning, Modeling, Tools **		**H**	**L**		
TLU	2.1.4	Targeted Open Space Protection		**M**	**M**		
TLU	**3.**	**INCREASING LOW-GHG TRAVEL OPTIONS**					

Option No.		GHG Reduction Policy Option	Priority for Analysis	Potential GHG Emissions Reduction	Potential Cost or Cost Savings	Ancillary Impacts, Feasibility Considerations	Notes
TLU	3.1	**Increase Transportation Funding for Efficient Modes**					
TLU	3.1.1	Maximize co-benefits from CMAQ funds in nonattainment areas		**L**	**L**		
TLU	3.1.2	Improve Transit Service (frequency, convenience, quality) **		**M**	**M**		
TLU	3.1.3	Transit Marketing and Promotion *		**M/H**	**L**		
TLU	3.1.4	Bike and Pedestrian Infrastructure		**L**			
TLU	3.1.5	Expand Transit Infrastructure (rail, bus, BRT) *		**M**	**M/H**		
TLU	3.1.6	HOV lanes		**L**	**H**		
TLU	3.1.7	"Fix-it-First"		**L/M**	**L**		
TLU	3.1.8	Transit Prioritization (signal prioritization, HOV lanes)		**L**	**L/M**		
TLU	3.1.9	Telecommute and Live-Near-Your-Work		**L**	**L**		
TLU	3.1.10	Car sharing		**L**	**L**	**Commercially provided at a profit; needs mostly just public access (parking)**	
TLU	3.1.11	E-Commerce		**L**			
TLU	3.2	**Incentives & Disincentives**					
TLU	3.2.1	Commuter Choice/Parking Cash Out		**H**	**L**		
TLU	3.2.2	VMT fee		**H**			
TLU	3.2.3	New investment / funding strategies		**L**			
TLU	3.2.4	Pay As You Drive Insurance		**H**	**L**		

Option No.		GHG Reduction Policy Option	Priority for Analysis	Potential GHG Emissions Reduction	Potential Cost or Cost Savings	Ancillary Impacts, Feasibility Considerations	Notes
TLU	3.2.5	Increased Fuel Tax (w/ targeted use of revenue towards travel alternatives)		**M**			
TLU	3.2.6	Location-Efficient Mortgages		**L**	**L**	**Available now; need additional promo**	
TLU	3.2.7	Congestion Pricing (or tolls) (w/ targeted use of revenue towards travel alternatives)		**L**			
TLU	3.2.8	Parking Pricing or Supply Restrictions		**H**			
TLU	3.2.9	Transit Repositioning		**M**			Combine with other transit, esp. 3.1.2-3?
TLU	3.2.10	Transit Pricing Incentives *		**M**	**L**		
TLU	3.2.11	VMT/GHG Offset Requirements for Large Developments		**L/M**	**L**		
TLU	3.2.12	Benefits for Low GHG Vehicles (preferential parking, use of HOV lanes, tolls)		**L**	**L**		
TLU	3.3	**Fuel Measures**					
TLU	3.3.1	Low-GHG Fuel Standard (e.g., renewable)		**L-H**		Emissions benefits will vary widely with renewable fuel type.	Need to ensure that emissions from alt-fuel production do not exceed benefits from use; may need additional R&D.
TLU	3.3.2	Renewable Fuels Motor Fuels Tax Exemption / credit				"	
TLU	3.3.3	Low-GHG Fuel for State and commercial Fleets (e.g., CNG, biodiesel) *		**L**		**". Some CNG bus expansion in the baseline in transit, schools, airports**	Biodiesel has various issues with both performance and fuel economy.
TLU	3.3.4	Biofuel expansion (biodiesel, CNG, LPG, cellulosic ethanol)		**L**		"	

Option No.		GHG Reduction Policy Option	Priority for Analysis	Potential GHG Emissions Reduction	Potential Cost or Cost Savings	Ancillary Impacts, Feasibility Considerations	Notes
TLU	3.3.5	Alternative Fuel Infrastructure Development *				"	
TLU	3.3.6	Purchase CO2 offsets for fuel use / Public facilities fee for fuel		**L/M**	**L**		
TLU	**4.**	**FREIGHT**					
TLU	4.1	**Vehicle Technology**					
TLU	4.1.1	Vehicle Technology Improvements (e.g., aerodynamics)		**L**		New EPA emission standards for heavy-duty engines take effect in 2007	
TLU	4.1.2	R&D on Low-GHG Vehicle Technology		**L**			
TLU	4.1.3	Low-sulfur diesel		**L**		New EPA fuel standards for low-sulfur diesel take effect in 2006.	
TLU	4.1.4	Black carbon control technologies (e.g., use of particulate traps, other complementary technologies) **		**U**		Large co-benefits in PM reduction.	
TLU	4.2	**Vehicle Operation**					
TLU	4.2.1	Freight Logistics Improvements/GIS		**L**			
TLU	4.2.2	Enforce Speed Limits		**L-M**			
TLU	4.2.3	Improve Traffic Flow		**L**			
TLU	4.2.4	Increased Size & Weight of Trucks		**L**	**L**	**Emissions benefits offset by mode shift from rail.**	
TLU	4.2.5	Increase the Number of Rest Areas		**L**			
TLU	4.2.6	Pre-clearance at Scale Houses		**L**			
TLU	4.2.7	Truck Stop Electrification **		**M**			

Option No.		GHG Reduction Policy Option	Priority for Analysis	Potential GHG Emissions Reduction	Potential Cost or Cost Savings	Ancillary Impacts, Feasibility Considerations	Notes
TLU	4.2.8	Enforce Anti-Idling ** (+ passenger idling, school bus idling)		**M**			
TLU	4.3	**Increasing Low-GHG Travel Options**					
TLU	4.3.1	Intermodal Freight Initiatives **		**L-M**			
TLU	4.3.2	Feeder Barge Container Service		**L**			
TLU	4.4	**Incentives & Disincentives**					
TLU	4.4.1	Procurement of Efficient Fleet Vehicles (public, private or other)					
TLU	4.4.2	Incentives to Retire or Improve Older Less Efficient Vehicles		**L**			
TLU	4.4.3	Maintenance and Driver Training					
TLU	4.4.4	Increased Truck Tolls or Highway User Fees		**L unless large enough to mode shift**			
TLU	4.5	**Intercity Travel: Aviation, High Speed Rail, Bus**					
TLU	4.5.1	High-speed Rail					
TLU	4.5.2	Integrated Aviation, Rail, Bus Networks		**M**			
TLU	4.5.3	Aircraft emissions		**L**			
TLU	4.5.4	Airport Ground Equipment		**L**			
TLU	4.6	**Off-Road Vehicles (construction equipment, out-board motors, ATVs, etc)**					

Option No.		GHG Reduction Policy Option	Priority for Analysis	Potential GHG Emissions Reduction	Potential Cost or Cost Savings	Ancillary Impacts, Feasibility Considerations	Notes
TLU	4.6.1	Incentives for Purchase of Efficient Vehicles/Equipment		**L**			
TLU	4.6.2	Improved Operations, Operator Training		**L**			
TLU	4.6.3	Maintenance Improvements		**L**			
TLU	4.6.4	Increased Use of Alternative Fuels or Low Sulfur Diesel		**L**			

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Agriculture, Forestry, and Waste Management (AFW) Technical Work Group Catalog of State Climate Mitigation Options

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AFW

Option No.	GHG Reduction Policy Option	Priority for Analysis	Potential GHG Emissions Reduction	Potential Cost or Cost Savings	Ancillary Impacts, Feasibility Considerations	Notes
AFW-1 Agriculture – Production of Fuels and Electricity						
1.1	Manure Digesters/Other Waste Energy Utilization		Medium	Neg to Low	• Linked with Option AFW2.2 below	• Hog farms a likely focus in NC; Poultry also important. • Recent proposed projects to incorporate this option with ethanol production (e.g. beef feedlots) in other states. • Includes manure combustion for energy recovery
1.2	Biodiesel Production (incentives for feedstocks and production plants)		Medium	Med to High	• Production from both virgin and waste vegetable oils	
1.3	Biomass Feedstocks for Electricity or Steam Production		Medium	Neg to Low	• Need to identify viable feedstocks and volumes [e.g., crop residue (wheat straw, corn stover) or energy crops (switchgrass)	• Linkage to Energy Supply TWG to determine availability of biomass plants • Linkage to RCI TWG to identify available capacity for biomass generated steam

Option No.	GHG Reduction Policy Option	Priority for Analysis	Potential GHG Emissions Reduction	Potential Cost or Cost Savings	Ancillary Impacts, Feasibility Considerations	Notes
1.4	Ethanol Production (incentives for production plants)		Medium	Med to High	• Starch- (e.g. corn-) and cellulosic production processes.	• Starch-based ethanol has small GHG benefits, while cellulosic ethanol has much higher benefits due to the energy required for ethanol production
1.5	Algaculture Incentives (production of biodiesel from algae)		?	?	• No commercial-scale facilities currently exist.	• Lab and field studies have estimated high energy return on investment yields • Potentially could be used in conjunction with power plants to reduce CO2 and NOx; or with water treatment facilities where waste is used as algal nutrients
AFW-2 Agriculture – Fertilizer and Manure Management						
2.1	Nutrient Management (improve efficiency of fertilizer use)		Medium	Low	• Significant opportunities beyond current practice?	
2.2	Manure Management (improve application methods)		Medium	?	• Linked with Option AFW1.1 above and 2.1, 2.3 below. • Co-benefits include reduction of ammonia and VOC emissions.	• Application improvement includes incorporation into soil, instead of surface spray/spreading.
2.3	Manure Composting		Low	?	• Potentially most feasible in the poultry, dairy or beef cattle sectors.	• Potential for reduction in CH4 emissions.
2.4	Change Feedstocks (optimize nitrogen for N_2O reduction)		Low to Medium	Low	• Co-benefits include reduction in ammonia emissions.	• Option includes supplements to reduce CH4 from enteric fermentation, as well as nitrogen efficiency to reduce downstream N20.

Option No.	GHG Reduction Policy Option	Priority for Analysis	Potential GHG Emissions Reduction	Potential Cost or Cost Savings	Ancillary Impacts, Feasibility Considerations	Notes
2.5	Reduce Non-Farm (Residential and Commercial) Fertilizer Use		Low	?	• Emissions from non-farm application are not currently in the inventory; unclear what the reductions and costs would be.	• Additional research needed on the levels of N20 emissions from lawns, golf courses, etc.
2.6	Using Bio-char as Soil Amendment		?	?	• Increase soil productivity and soil carbon storage	• Need information on the sources of bio-char and its impacts.
AFW-3 Agriculture – Soil Carbon Management						
3.1	Conservation Tillage/No-Till (carbon sequestration and reduced energy use)		Medium	Low	• Significant opportunities beyond current practice?	• Need estimates on current practices/potential for increased acreage.
3.2	Reduce Summer Fallow (increase soil C content, reduce N_2O emissions)		?	?	• Significant opportunities beyond current practice?	• Need estimates of fallow summer acreage
3.3	Increase Winter Cover Crops (increase soil C content, increase soil N content)		?	?	• Significant opportunities beyond current practice?	• Need estimates of winter acreage available for cover crops
3.4	Improve Water and Nutrient Use (to minimize soil C loss)		Low	Low	• Significant opportunities beyond current practice?	
3.5	Rotational Grazing/Improve Grazing Crops and/or Management		Low	Low	• Is impaired rangeland an issue in NC?	
3.6	(Additional option, if/as suggested)					
AFW-4 Agriculture – Land Use Change						
4.1	Convert Land to Grassland or Forest		Medium	?		• Need estimates of marginal agricultural land with the potential for conversion. • "Current Use Valuation" Law
4.2	Preserve Open Space/Agricultural Land		High	?	• Reductions occur both from higher retention of carbon in soil and lower transportation activity.	

Option No.	GHG Reduction Policy Option	Priority for Analysis	Potential GHG Emissions Reduction	Potential Cost or Cost Savings	Ancillary Impacts, Feasibility Considerations	Notes
4.3	Promote "No Net Loss" of Agricultural Land		High	?	• Reductions occur both from higher retention of carbon in soil and lower transportation activity.	• "Current Use Valuation" Law
AFW-5 Agriculture – Farming Practices						
5.1	Convert Diesel Farm Equipment to LNG/CNG, Hybrid Technology		Low	Med to High	• LNG/CNG engines or engine conversions reduce BC emissions • Availability of diesel hybrid equipment for farm applications?	•
5.2	Programs to Support Organic Farming		Medium	Low	• Reductions occur via lower intensity agricultural practices (nutrient/pesticide application, reduced tillage)	• Weed management • Transgenic crops • Integrated pest management • Bed/row size or spacing • Application efficiencies (low volume sprayers, etc.)
5.3	Programs to Support Local Farming/Buy Local		Low - Med	?	• Reductions occur through lower transport related emissions.	•
5.4	Programs to Encourage Local Oilseed Pressing for Bio-diesel Production and Use as Farm Equipment Fuel		Low	?	•	•
5.5	Policies to Promote On-Farm Bio-diesel Use		Low - Med	?	•	• Linkage to 5.4
5.6	Promotion of Less-Centralized Processing and Storage Infrastructure for Ag. Products and Commodities		Low - Med	?	•	• Linkage to 5.3
5.7	Policies to Encourage Use of Rail and Water Transportation by Agriculture		Low - Med	?	•	• Linkage to 5.3
5.8	Increase Number of Farm Production/Market Facilities Around Population Centers		Low - Med	?	•	• Linkage to 5.3

Option No.	GHG Reduction Policy Option	Priority for Analysis	Potential GHG Emissions Reduction	Potential Cost or Cost Savings	Ancillary Impacts, Feasibility Considerations	Notes
5.9	Programs to Support Buying Local Agricultural Products		Low-Med	?	• GHG reductions occur through lower transportation emissions.	• Note relationship to Option 5.3 above.
AFW-6 Forestry – Biomass Protection and Management						
6.1	Forest Protection – Reduced Clearing and Conversion to Nonforest Cover		High	Low	• Depends on business as usual rates of land clearing and viable alternatives	• "Current Use Valuation" Law
6.2	Increase Maintenance of Urban and Residential Trees		Low	Low to high	•	•
6.3	Afforestation and/or Restoration of Nonforested Lands		Low to high	Low	• depends on available acreage and risk	•
6.4	Reforestation/Restoration of Managed Stands		Low to high	Low	• depends on available acreage and risk	•
6.5	Increased Stocking of Poorly Stocked Lands		Low to high	Low	• depends on available acreage and risk	•
6.6	Age Extension of Managed Stands		Low	Low to high	• involves significant tradeoffs with carbon savings from harvested wood products, as well as ecological risk	•
6.7	Thinning and Density Management of Managed Stands		High	Low to high	• cost and technology barriers to market use of harvested biomass may be high; supply potential is high	•
6.8	Fertilization and Waste Recycling		Low	Low to high	• site and situation specific	•
6.9	Expand Short Rotation Woody Crops (for fiber and energy)		Low to medium	Low to high	• depends on available acreage and market demand	•
6.10	Expanded Use of Genetically Preferred Species		Low	Low	•	•

Option No.	GHG Reduction Policy Option	Priority for Analysis	Potential GHG Emissions Reduction	Potential Cost or Cost Savings	Ancillary Impacts, Feasibility Considerations	Notes
6.11	Modified Biomass Removal Practices (reduced decay and energy use)		Low	?	• may be opportunities to use biofuels for equipment	•
6.12	Fire Management and Risk Reduction Programs		High	Low to high	• implementation and market barriers may be significant, potential is high if biomass is directed to constructive reuse	•
6.13	Ecosystem Health Risk Reduction Programs (pest/disease, invasive species)		High	Low to high	• implementation and market barriers may be significant, potential is high if biomass is directed to constructive reuse	•
6.14	Drought Management Programs (tree selection, placement, protection)		High	Low to high	• implementation and market barriers may be significant, potential is high if biomass is directed to constructive reuse	•
6.15	Flood and Riparian Management Programs (tree selection, placement, protection)		Low	Low to high	• depends on available acreage	•
6.16	Watershed Management Programs (stand retention, enhancement and management)		Low to high	Low to high	• depends on available acreage and forest health issues	•
6.17	Habitat Management Programs (stand retention, enhancement and management)		Low to high	Low to high	• depends on available acreage and forest health issues	•

Option No.	GHG Reduction Policy Option	Priority for Analysis	Potential GHG Emissions Reduction	Potential Cost or Cost Savings	Ancillary Impacts, Feasibility Considerations	Notes
6.18	Policies to Promote Forest Soil Carbon Management/Build-up		?	?	• note an element of this option can be the protection of carbon found in wetlands/ marshes (C losses from peat, following drainage)	•
6.19	Application of Waste to Forested Lands		?	?	•	•
6.20	Restoration of Diverse Forest Systems		?	?	• option targets forest systems that are not managed by federal or state agencies.	• Linkage to Option 6.4
AFW-7 Forestry - Wood Products and Waste						
7.1	Improved Mill Waste Recovery		Low to high	Low to high	• technology and market dependent	•
7.2	Improved Logging Residue Recovery		High	Low to high	• technology and market dependent	•
7.3	Expanded Use of Wood Products for Building Materials		Med to High	Low to high	• technology and market dependent	• Supplant use of non-wood products (e.g. steel, cement) with wood products, where possible.
7.4	Expanded Use of State and Locally-Grown Wood Products		Low to high	Low to high	• technology and market dependent	• Reduces transportation-related emissions and embedded energy.
7.5	Promotion of Integrated Biorefinery Processes		?	?	•	•
AFW-8 Forestry – Energy Production						
8.1	Expanded Use of Forest Biomass Feedstocks for Electricity (fuel switching)		High	Low	• technology and market dependent	•
8.2	Expanded Use of Forest Biomass Feedstocks for Residential, Commerical/Institutional, or Industrial Heating		High	Low	•	•

Option No.	GHG Reduction Policy Option	Priority for Analysis	Potential GHG Emissions Reduction	Potential Cost or Cost Savings	Ancillary Impacts, Feasibility Considerations	Notes
8.3	Improved Efficiency of Wood Burning Stoves and Direct Heat		Low to Medium	?	•	•
8.4	Improved Energy Capture from Wood Waste Combustion		Low to high	?	• technology and market dependent	•
8.5	Improved Commercialization of Biomass Gasification and Combined Cycle		Low to high	Med to High	• requires improved technology and market incentives	•
8.6	Promote Cellulosic Ethanol Production		Med to High	Med	•	•
AFW-9 Waste Management – Waste Management Strategies						
9.1	Advanced Recycling and Composting		Low	Low	•	•
9.2	Advanced Municipal Solid Waste Management Practices (e.g., bioreactors)		Low to Med	Neg to Low	•	•
9.3	Source Reduction Strategies		Low	Low	•	•
9.4	Resource Management Contracting		?	?	•	•
9.5	Manure Digesters		Med	Neg to Low	•	• Also under Agriculture (Option AFW1.1)
9.6	Increased Collection of Recyclables		?	?	•	•
9.7	Increased Marketing of Recyclable Materials and Products		?	?	•	•
AFW-10 Waste Management – Landfill Gas Strategies						
10.1	Flare Landfill Methane at non-NSPS (smaller) sites		Low	Med to High	• Federal New Source Performance Standards and Emissions Guidelines require methane capture at larger landfills.	• Should be limited to consideration at sites where energy can not be recovered feasibly; • Need to consider energy required to collect CH4.
10.2	Methane and Biogas Energy Programs (Waste Water Processes)		Low to Med	Neg to Med	• Methane conversion to motor fuels, electricity, steam, or space heat are examples	• This option covers methane from waste water treatment, while 10.3 covers landfills.

Option No.	GHG Reduction Policy Option	Priority for Analysis	Potential GHG Emissions Reduction	Potential Cost or Cost Savings	Ancillary Impacts, Feasibility Considerations	Notes
10.3	Convert Landfill Methane to Electric Power, Space Heat, or LNG		Low to Med	Neg to Low	•	•
AFW-11 Waste Management – Wastewater Activities						
11.1	Energy Efficiency Improvements		Low	Neg to Low	•	•
11.2	Lower Waste Processing Needs (lower water consumption, waste production)		Low	?	•	•
11.3	Install Digesters and Turbines		Low to Med	?	•	•
11.4	Install Fuel Cells		Low to Med	?	•	•

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Cross-Cutting Issues (CC) Technical Work Group
Catalog of State Climate Mitigation Options

Draft Version 3d – July 11, 2006

Definition of "Priorities for Analysis":

- **High:** High priority options will be analyzed first.
- **Medium:** Medium priority options will be analyzed next, time and resources permitting.
- **Low**: Low priority options will be analyzed last, time and resources permitting.

Notation of Options:

*** Options marked with an asterisk (*) indicate options that are at least partially "base case" policies, i.e., that have been considered or undertaken at some level in North Carolina.**

**** Options marked with a double asterisk (**) indicate options that are included as recommendations in the September 1, 2005 NC DENR Report under the Clean Smokestacks Act of 2002.**

***** Options marked with a triple asterisk (***) indicate options that are included as recommendations made to the North Carolina Legislative Commission on Global Climate Change (LCGCC)**

Option Number	Climate Mitigation Option	Priority for Consideration	Feasibility Considerations	Notes
CC-1	**INVENTORIES AND FORECASTING**			
1.1	Establish GHG emission inventory function at DAQ	•	•	• (CSA recommendation for permitted sources moved to CC-2.)
1.2	Establish GHG emissions forecasting function within State Government	•	•	•
CC-2	**REPORTING**			
2.1	Establish a GHG reporting program	•	•	• (Follows on CSA recommendation A-4.) • (Details about who, what, when, etc. will be addressed in the design characteristics matrix.) • This will address Dr. Rubin's recommendation to the LCGCC for mandatory GHG reporting***
CC-3	**REGISTRY**			
3.1	Establish a GHG registry for NC (possibly in concert with other states)	•	•	• (Referenced in CSA Rec. A-4) • Note: Cap and trade system per Dr. Rubin's recommendation to the LCGCC may be considered under this option***
CC-4	**EDUCATION** ***(This general option to be discussed further re direction & organization.)***			
4.1	Reinforce sources of GHG, need for State Energy Plan implementation**	•	•	• From Recommendation LT -2 in the Sept. 1, 2005 CSA report.
4.2	Promote clean fuel technologies**	•	•	•
4.3	Promote energy-tech economic development**	•	•	•

Option Number	Climate Mitigation Option	Priority for Consideration	Feasibility Considerations	Notes
4.4	Promote R&D & demo projects for economic development**	•	•	•
4.5	Extend training programs for RCI building operators**	•	•	• From "Recommendation A-1" and "Recommendation LT-1" in the Sept. 1, 2005 CSA report.
4.6	Public education initiatives**	•	•	• From "Recommendation A-7" in the Sept. 1, 2005 CSA report and State Energy Plan (SEP).
4.7	Promote green power in order to expand subscription**	•	•	• From "Recommendation A-5" in the Sept. 1, 2005 CSA report.
4.8	Promote combined heat and power (CHP) in order expand its use and technological penetration**	•	•	• From "Recommendation A-1" in the Sept. 1, 2005 CSA report.
4.9	Require environmental disclosure on utility bills**	•	•	• From Appendix C – January 2005 Revisions to the State Energy Plan (SEP), Alternative Energy Sources: Exec-10
4.10	Promote local farm produce**	•	•	• Appendix D – Preliminary Analysis of Selected Policy Options: Agriculture and Forestry, Support Local Farming/Buy Local
4.11	Augment existing education efforts**	•	•	• From "Recommendation A-7" in the Sept. 1, 2005 CSA report and State Energy Plan (SEP).
4.12	Add GHG to Air Awareness efforts**	•	•	• From "Recommendation A-7" in the Sept. 1, 2005 CSA report and State Energy Plan (SEP).
4.13	Provide information that helps inform sources of the potential advantages of registering GHG emission reductions	•	•	• From "Recommendation A-4" in the Sept. 1, 2005 CSA report.

Option Number	Climate Mitigation Option	Priority for Consideration	Feasibility Considerations	Notes
4.14	Encourage cities to join ICLEI's[1] Cities for Climate Protection program	•	•	•
4.15	Encourage cities to join the U.S. Mayors Climate Protection Agreement[2]	•	•	•
4.16	Technology Options***	•	•	• From Dr. Rubin's recommendations to the LCGCC: • Direct Government funding of R&D *(may be more appropriate at federal level)* • Direct or Indirect support for commercialization and production; Indirect support for development *(may be more appropriate at federal level)* • Support for learning and diffusion of knowledge
CC-5	**ADAPTATION**			
5.1	Recommend an approach for NC to identify and plan for potential, long-term effects of climate change on society	•	•	• CAPAG noted the need to include all effects and impacts.
CC-6	**OPTIONS FOR GOALS OR TARGETS (IN SUPPORT OF THE LEGISLATIVE COMMISSION ON GLOBAL CLIMATE CHANGE [LCGCC])**			
6.1	Assist CAPAG in framing and data analysis of possible statewide GHG reduction goals or targets	•	•	•

[1] See www.iclei.org.
[2] See http://www.ci.seattle.wa.us/mayor/climate/.

Appendix K
References

The following is an alphabetical listing of the scientific and technical citations referenced in each section of the report. Because Web sites change over time, some of the Internet links in this appendix may become inoperable in the future.

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Note: As stated on page 1,because Web sites change over time, some of the Internet links in this appendix may become inoperable in the future.