



Preliminary Analysis of Selected Policy Options to Reduce Greenhouse Gas Emissions

**Center for Climate Strategies
August 2005**



Note: This document was prepared to document and support the preliminary analyses performed in efforts to produce the final report for the Clean Smokestacks Act for September 2005. It is expected to be further developed and revised as a result of feedback from stakeholders and continuing development of a North Carolina Climate Action Plan for.

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Overview

This report contains preliminary analysis of selected climate mitigation policy options. The constrained time and resources available for the report limited the depth, breadth, and detail of the analysis performed. The results below should be taken as suggestive of the magnitudes of impacts one might expect from various policy options. These results can be refined and updated in the future in the course of the stakeholder process the DENR aims to conduct. In many cases, better data and data more specific to NC can be obtained.

Selected options were analyzed in three sectors: agriculture and forestry; energy supply and demand; and transportation and land use. Effort was made to provide the following information for each option:

- Policy description
- Description of existing “Business As Usual” (BAU) Policies/Programs
- Types(s) of GHG benefit(s)
- Ancillary benefits and/or costs
- Estimated GHG savings and costs per ton CO₂e
- Data sources, methods and assumptions
- Key uncertainties
- Estimation of ancillary (non-GHG) benefits and costs:
- Feasibility issues

However, in many cases, the authors had to simply put “TBD” (to be determined) where some information fell beyond the scope of the analysis at this time.

Chapter 1 - Agriculture and Forestry

Farm Waste to Energy Conversion

Policy Description: This policy incorporates a wide range of farm waste conversion options. Options could include incentivizing or mandating the use of animal waste or crop waste for energy production purposes. Energy production could include the production of electricity, fuel for process heat, or fuel for space heat. The policy reduces CO₂e in two ways: direct reductions in methane (CH₄) emissions from farm waste; and offsetting the use of fossil fuels from the energy produced. Production of liquid biofuels is handled in a separate policy option: Biofuels Development.

For this example, the focus is on reducing CH₄ from hog farms. The policy would require hog farms with >250 head to adopt manure management strategies that allow for capture of emissions from waste management systems. The policy would also promote the use of the captured methane for energy production (in this example, electricity). Costs and benefits are based on anaerobic digestion of hog waste followed by energy recovery of biogas using internal combustion engines.

BAU Policies/Programs: TBD.

Types(s) of GHG Benefit(s): CH₄ reduction from each facility >250 head. For facilities that utilize energy capture, reduced CO₂ emissions from displaced energy needed for electricity generation, space heating, or other energy use. Approximately 9.9 million head of hogs in NC produce about 4.05 MMtCO₂e.

Ancillary Benefits and or Costs: Reduction of ammonia and VOC emissions. Reduction of odors. Increase in NO_x emissions from combustion sources.

Estimated GHG Savings and Cost per Ton CO₂e: Reductions for this example action are initially estimated here at 3.3 MMtCO₂e for the CH₄ reductions. Another 0.45 MMtCO₂e are reduced by offsetting 801 GW-hr of fossil fuel-based electricity. Costs were not estimated at the state level, but have been estimated based on an example project (see next section). A net cost savings is expected.

Data Sources, Methods and Assumptions:

- **Data Sources:** These estimates are based on a presentation by Leonard Bull of North Carolina State University,¹ and a case study data from the Midwest Combined Heat and Power Application Center².
- **Quantification Methods:** Used estimates on manure production, heat content, and electrical conversion efficiency to estimate the amount of electricity produced and

¹ Leonard Bull, *Animal and Poultry Waste-to-Energy*, PowerPoint presentation, North Carolina State University, 2005.

² Midwest CHP Application Center, *Colorado Pork LLC, 80 kW CHP Application*, 2005.

CH₄ reduced via anaerobic digestion and electricity production from biogas. Cost information for an example project (see below) came case study cited above.

- **Key assumptions:** 90% of hogs are on farms with >250 head. Anaerobic digestion and electricity production is technically feasible at all facilities >250 head. No farms >250 head are currently controlling emissions. 90% of manure heat content converted to biogas. 90% of biogas generated is captured.
 - **Cost estimate for an example project:** Costs are based on a similar project constructed in Colorado³. At a 5,600 head sow farrow to wean operation, an anaerobic digester and combined heat and power plant was constructed. Methane from the digester was routed to a reciprocating engine and generator (80kW). Thermal energy from the engine was recovered and used to heat the anaerobic digester. Total capital costs were \$375k. The equipment produced an annual savings of \$48.7k (\$38.7k in reduced electricity costs; and \$10k reduction in lagoon clean-out costs). A 30 kW microturbine has also recently been added to the operation; however the additional costs/benefits of this system are not included here.

Based on the cost data above, a 7% interest rate, and a 15 year equipment life, an annualized cost of -\$6,827 was calculated. Emission reductions for this project are estimated to be 2,300 MTCO_{2e}. Therefore, the cost effectiveness is -\$2.91/MTCO_{2e}, i.e., a net savings to the farmer.

Key Uncertainties:

- **Benefits:** 3.3 MMtCO_{2e} reduced assumes that no farms currently control emissions; technology is technically and economically feasible at all farms >250 head.
- **Costs:** Assume that costs associated with the Colorado project are representative of what could be achieved at any farm >2,500 head in NC.

Estimation of Ancillary Benefits and Costs:

- **Benefits:** co-reduction of ammonia, VOC and odors; production of electricity, steam or space heat.
- **Costs:** Costs for ancillary benefits not quantified; however they would also be negative, since the project results in a cost savings.

Description of Feasibility Issues: TBD.

Biofuels Development

³ *Op. cit.*

Policy Description: Institute programs to expand the production of biofuels in NC. Liquid fuels made from biomass are referred to as biofuels. The two most common biofuels used in the United States today are ethanol and biodiesel. While they can each be used as alternative fuels, both are more frequently used as additives to conventional fuels (gasoline and diesel). Commercial biodiesel fuel is typically a mixture of conventional diesel fuel and 20% biodiesel by volume (referred to as B20); however 100% biodiesel can also be used in both onroad and nonroad diesel equipment.

Ethanol is often blended with gasoline (at up to 10% by volume) to increase the oxygen content of the fuel and reduce emissions of carbon monoxide. Ethanol is most often produced from corn or other starches. Technologies are currently being developed to economically produce ethanol from other biomass, including crop residues and wood waste. There is still a lot of debate in the scientific community about the net CO₂ benefits of ethanol fuels (due to the amount of energy needed to produce ethanol).

GHG emissions are reduced by offsetting the use of petroleum-derived gasoline and diesel. The costs and benefits for this policy description are based on the production of a specific volume of biodiesel from vegetable oils, waste vegetable oil, and other feedstocks. Note that Smithfield Farms has also developed a large-scale plant in Utah to convert hog waste into methanol, which is then used in biodiesel production. Also, two biodiesel plants have been proposed in NC: Blue Ridge Biofuels in Asheville and Grain Growers Cooperative in Mount Olive. Proposed plants are those biodiesel companies who are in the process of raising equity, permitting or construction for their facility but are not yet actively producing biodiesel.⁴

BAU Policies/Programs: TBD.

Types(s) of GHG Benefit(s): Reduction in CO₂ emissions by offsetting fossil fuel-derived diesel use.

Ancillary Benefits and or Costs: Lower criteria pollutant emissions (NO_x, potentially PM). For users of biodiesel, some evidence of better engine performance due to better lubricity of biodiesel fuels.

Estimated GHG Savings and Cost per Ton CO₂e: A single 15 million gallon/yr facility would produce enough biodiesel to offset 0.15 MMTCO₂e. The costs to produce biodiesel in a facility of this size are estimated to be between \$1.48 - \$1.85/gallon suggesting that biodiesel is cost-competitive with ordinary diesel, especially given current trends in world oil prices (these estimates are comparable to current diesel fuel prices, when taxes and transportation costs are taken into account). Costs per ton CO₂e are to be determined, and must take into account a lifecycle analysis.

Data Sources, Methods and Assumptions:

⁴ National Biodiesel Board, *Current and Proposed Biodiesel Plants*, www.biodiesel.org/buyingbiodiesel/producers_mapeters/ProducersMap-existingandpotential.pdf.

- **Data Sources:** University of Georgia (UGA) study.⁵
- **Quantification Methods:** Standard CO₂ emission factor for diesel fuels; cost information from UGA study.
 - UGA study estimated that a biodiesel plant with a capacity of 15 million gallons/year and feedstock costs of \$0.15-\$0.20/lb could produce biodiesel at a cost of \$1.48 - \$1.85/gallon (capital costs estimated at \$9.6 million). Diesel fuel has a CO₂ emission factor of 10.05 kg/gallon.
 - Costs to produce biodiesel in smaller plants (e.g., 0.5 – 3 million gallons/yr) were estimated to be about 10 to 40% higher than the 15 million gallon facility. A 30 million gallon/yr facility was not much more cost efficient than the 15 million gallon/yr facility.
 - A 15 million gallon/yr facility would produce enough biodiesel to offset 0.15 MMTCO₂e.
- **Key assumptions:** Cost information provided from UGA is applicable to NC and still valid.

Key Uncertainties:

- Benefits: TBD.
- Costs: Degree to which UGA cost information is appropriate for NC. Costs are based on the annualized costs of building and running the biodiesel plant, not the costs to the state or local area in incentives designed to promote building the plant.

Estimation of Ancillary Benefits and Costs:

- Benefits: TBD.
- Costs: TBD.

Description of Feasibility Issues: Biodiesel needs to be cost competitive with conventional diesel fuel in order to be marketable (without subsidies). The UG study indicated that this is feasible. Diesel fuel costs are currently about \$2.33 in the Southeast.⁶ After subtracting 27% of this cost for taxes and distribution/marketing (average for the U.S.), the conventional diesel price is \$1.71/gallon. For comparison to the UGA study, another estimate indicated that the estimated cost of conventional biodiesel production at that time was about \$2.50/gallon (no details on plant size or feedstock costs), and that a new process (lab scale demonstration) was capable of producing biodiesel at less than \$0.70/gallon.⁷

⁵ G.A. Shumaker, J. McKissick, C. Ferland, and B. Doherty, *A Study on the Feasibility of Biodiesel Production in Georgia*, University of Georgia, date unknown.

⁶ Energy Information Administration, *Gasoline and Diesel Fuel Update*, 2005.

⁷ "Production of a cost-competitive biodiesel fuel alternative to petroleum diesel", *Environmental Science & Engineering*, May 2001.

It is worthy to note that NC is currently one of the larger users among U.S. states of biodiesel, although none is currently produced in the state.⁸ Current annual statewide usage estimates are 5 million gallons of B20 (1 million gallons of biodiesel). The usage has jumped more than 10-fold since 2001.

Fertilizer Management for N₂O Reduction

Policy Description: Improve efficiency of synthetic fertilizer and manure application. A portion of the nitrogen applied to the soil is subsequently emitted as N₂O (a GHG) through denitrification. Therefore, a reduction in the quantity of fertilizer applied, measures that improve nitrogen uptake, or measures that increase nitrogen in the soil can reduce N₂O emissions. The exact measure needed varies by climate, crop, soil type, and other factors. Examples include substituting one type of fertilizer for another (e.g. ammonium-based fertilizers for nitrate fertilizers), altering the timing or number of applications, altering cover crops and rotational schemes, providing adequate drainage, and by increasing soil testing to improve efficiency (and reduce unnecessary applications).

The policy could be carried out by requiring farmers producing crops covering a certain acreage threshold or applying fertilizers in excess of a certain amount to prepare and submit a Fertilizer (or Nutrient) Management Plan (NMP). Implementation would occur through local Agricultural Extension Offices. Estimates of the costs and benefits of this measure are based on fertilizer (nitrogen) application reductions.

BAU Policies/Programs: Current policies focus on limiting nitrogen loadings to surface waters. Policies currently in place include the Neuse Agricultural Rule which mandates that all persons engaging in agricultural operations in the Neuse River Basin shall collectively achieve and maintain a 30% net nitrogen loading reduction by 2003. This reduction is to be achieved by a combination of standard best management practices that include riparian buffers, nutrient management plans, and water control structures.⁹

Types(s) of GHG Benefit(s): Reduction in N₂O emissions through lower nitrogen application rates or other management practice.

Ancillary Benefits and or Costs: Lower ammonia emissions; less N run-off to surface waters; lower fertilizer costs to farmers.

Estimated GHG Savings and Cost per Ton CO₂e: The Neuse River Crop Management Project (NRCMP) at North Carolina State University estimated that NMPs could reduce N application rates by 10-20%.¹⁰ N₂O reductions are assumed to be directly

⁸ Tobin Freid, Triangle J Council of Governments, personal communication with S. Roe, E.H. Pechan & Associates, Inc., August 2005.

⁹ Neuse River Crop Management Project, North Carolina State University, information obtained from website accessed August, 2005.

¹⁰ *Op. cit.*

proportional to lower nitrogen application (via better uptake by crops). From EPA's SGIT, N₂O emissions from agricultural soils associated with fertilizer application were about 0.55 MMTCO₂e in 2000 (note that emissions average nearly twice this amount from 1990 to 1999; much lower fertilizer application is shown in the SGIT default data in 2000).

10 to 20% reductions in fertilizer application rates statewide could reduce N₂O emissions by 0.05 to 0.11 MMTCO₂e/yr, if the policy is applied to all farmers. The estimate does not take into account any growers that currently use NMPs and that have already achieved reductions as a result.

NRCMP also estimates that the costs of implementing Nutrient Management Plans are negligible and are offset by lower fertilizer usage.¹¹ The NC Cooperative Extension or the federal Natural Resources Conservation Service will verify the plan at no charge. The NC Department of Agriculture will provide a free soil test. For the purposes of this analysis, the time required by the farmer to prepare the plan is assumed to be offset by lower fertilizer costs. Therefore, the costs are assumed to be \$0. This assessment does not quantify the additional emissions and costs associated with multiple fertilizer applications (from a baseline of a single application), if those are called for in the Nutrient Management Plan.

Data Sources, Methods and Assumptions:

- **Data Sources:** Information from NRCMP was used to provide this initial estimate of reductions and costs;
- **Quantification Methods:** Emissions were taken from the EPA State Greenhouse Gas Inventory Tool.¹² Reductions are assumed to be equal to the reduction in fertilizer application (10-20%) achieved by implementing a Nutrient Management Plan;
- **Key assumptions:** Policy is implemented by all growers. Costs are negligible and completely offset by reduced fertilizer application.

Key Uncertainties:

- **Benefits:** N₂O emission reductions are equivalent to reductions in nitrogen application rates. Amount of cropland where NMPs are already used to manage fertilizer application.
- **Costs:** Costs for implementing NMPs are negligible.

Estimation of Ancillary Benefits and Costs:

¹¹ Neuse River Crop Management Project, North Carolina State University, *Cost and Benefits of Best Management Practices to Control Nitrogen in the Piedmont*, accessed August 2005

¹² See www.epa.gov/ttn/chief/conference/ei12/green/choate.pdf.

- **Benefits:** 10-20% reductions in ammonia emissions would also occur, if fertilizer application rates are reduced. Reductions in N runoff to surface waters can not be estimated based on available information.
- **Costs:** To be determined.

Description of Feasibility Issues: TBD.

Soil Carbon Sequestration in Agricultural Soils

Policy Description: Cultivation practices that result in less disruption of the soil or that increase soil organic carbon content (stock) through carbon deposition can reduce its rate of loss (flux) to the atmosphere. These cultivation practices are often referred to as conservation tillage. By definition, conservation tillage leaves at least 30 percent of the soil covered by crop residues.¹³

A specific implementation program for conservation tillage is not identified here. Instead, a recommended program goal of 500,000 acres of cropland brought into new management practices, which results in a total per acre soil carbon storage rate improvement of 2 percent over a 10 year time period. Implementation would occur through local Agricultural Extension Offices.

BAU Policies/Programs: Conservation tillage has been already been adopted for at least some crops in North Carolina (corn, wheat, soybeans, vegetables); however the level of penetration is still under investigation.

Types(s) of GHG Benefit(s): Reduction in CO₂ emissions through lower carbon flux from agricultural soils.

Ancillary Benefits and or Costs: Potential for lower GHG emissions through lower intensity tillage practices, which lower fuel consumption. Data needed to quantify these reductions have not been identified. Less soil erosion and run-off to surface waters (including associated nitrogen). In the first few years, 5 to 10% lower yields might be experienced by some growers.¹⁴ More information on benefits/dis-benefits can be found on the North Carolina State University Sustainable Practices website.¹⁵

In conservation tillage, the new crop is planted into the stubble from the previous crop or into small strips of tilled soil. In some practices weeds are controlled with cover crops or herbicides rather than by cultivation. Hence, a higher dependence on herbicides could result in certain cases.¹⁶

¹³ Mary Peet, *Conservation Tillage*, North Carolina State University, October 4, 2001, information obtained from website, accessed August 2005.

¹⁴ Holly Wagner, "No-Till Farming Offers a Quick Fix to Help Ward Off Host of Global Problems", Ohio State University Research News, April 15, 2004.

¹⁵ Mary Peet, *op. cit.*

¹⁶ *Op. cit.*

Estimated GHG Savings and Costs per Ton CO₂e: In 2004, roughly 3 million acres were planted in corn, soybeans, wheat, and vegetables.¹⁷ Assuming that 37% of these acres are already cultivated using conservation tillage practices (equal to the average for the U.S. as a whole¹⁸), that leaves about 1.9 million acres. It is further assumed that at least 25% of these acres can adopt conservation tillage practices (leaving around 500,000 acres). The table below provides a summary of assumptions and results for the estimated carbon sequestration associated with conservation tillage practices.

Acres of cropland converted - potential	500,000
Acres of cropland converted per year	50,000
Potential percent increase in soil organic matter	2.00%
Potential percent increase in organic carbon	1.20%
Pounds soil per acre (top 12 inches) ^a	2,000,000
Initial soil organic matter content ^b	0.50%
Pounds soil organic matter per acre	10,000
Percent SOM that is Organic Carbon ^c	60.00%
Potential annual rate of SOM increase	0.20%
Pounds OC sequestered per acre per year	2400
Total lbs OC sequestered Year 1	120,000,000
MMTCO ₂ e sequestered per year (year 1)	0.20
Total MMTCO ₂ e sequestered after 10 years	20.0
No Till cost per acre - avg (ERS) ^d	\$ 28.00
No Till cost per acre - high (ERS) ^d	\$ 98.00
Annual Cost per Ton CO ₂ e - avg. Year 1	\$ 7
Annual Cost per Ton CO ₂ e - high Year 1	\$ 25

^a Source: MEDEP, 2004.

^b Assumed.

^c Assumed based on a ratio of 1:1.7 organic carbon to organic matter used in the literature.

^d Source: USDA Economic Research Service, Environmental Quality Incentives Program, Farm Service Agency database. Average cost per acre is for “residue management – no till and strip till” for all states in the database. High cost is the value for North Carolina, which is much higher than for other reported states. Further research could illuminate the reason for the high cost.

Data Sources, Methods and Assumptions:

- Data Sources:** The analysis conducted for the Maine Department of Environmental Protection¹⁹ provided information on the amount of potential increase in soil organic matter content, soil density, and cost data (cost data taken from the U.S. Department of Agriculture Economic Research Service; USDA ERS). Data on total crop land in NC came from the NC Department of Agriculture.²⁰ Assumptions on the amount of cropland where conservation tillage was not currently practiced was based on a national estimate. The fraction of the remaining cropland (where conventional tilling

¹⁷ North Carolina Department of Agriculture & Consumer Services (NCDOA), *Annual Summary: Crop Estimates, North Carolina, 2002-2004*.

¹⁸ Holly Wagner, *op. cit.*

¹⁹ Maine Department of Environmental Protection, 2004. *Maine Greenhouse Gas Action Plan Development Process, Review Draft, May 27, 2004*.

²⁰ NCDOA, *op. cit.*

is assumed) that can be cultivated using conservation tillage practices (25%) is assumed.

- **Quantification Methods:** Develop an estimate on the acreage of cropland, where conservation tillage practices can be implemented. Estimate the initial amount of organic material present in the top foot of soil. Estimate the amount of organic material present after conservation tillage has been practiced for 10 years. Calculate the increase in organic material mass. Convert organic material to organic carbon. Convert organic carbon to CO₂e.
- **Key assumptions:** Amount of cropland where conservation tillage is already practiced; amount of remaining cropland where conservation tillage can be practiced; 2% increase in soil organic matter over 10 years is attainable.

Key Uncertainties:

- **Benefits:** See key assumptions above.
- **Costs:** Cost data from the USDA ERS on conservation tillage are representative of costs that would be incurred in NC.

Estimation of Ancillary Benefits and Costs:

- **Benefits:** Reduced soil erosion, potential lower yields in initial years. Increases/decreases in CO₂e associated with different equipment usage/activity levels in conservation tillage versus conventional tillage practices. None of these benefits/dis-benefits have been quantified.
- **Costs:** TBD.

Description of Feasibility Issues: TBD.

Support Local Farming/Buy Local

Policy Description: Increased purchase of locally grown produce can potentially reduce emissions associated with the transport of agricultural products by ground or airfreight. Modification of haul distances and freight modes (air to ground) can reduce diesel fuel use. This policy builds on the BAU programs described below to expand purchases of locally grown products. Limited resources did not allow for the formulation of a proposal for this option, and the below calculations are offered as a sample, placeholder assumption for further discussion. It is based on an Iowa study that evaluated shifting ten percent of produce to local grown sources, and has been adjusted by population factor to North Carolina.

BAU Policies/Programs: The purpose of the USDA Resource Conservation and Development (RC&D) program is to accelerate the conservation, development and utilization of natural resources, improve the general level of economic activity, and to

enhance the environment and standard of living in designated RC&D areas. These programs can, potentially, be used to encourage local farming.

The North Carolina Department of Agriculture and Consumer Services (NCDOA) started the “Goodness Grows in North Carolina” program in 1985 as a way to market homegrown commodities.²¹ Any producer or processor in North Carolina may join the program free of cost and use the “Goodness Grows” logo as long as their product meets the following requirements:

- Product must be top quality (must meet all local, state and federal requirements)
- Product must be produced or processed in North Carolina.
- If the item is processed, it must contain North Carolina agricultural products when available.

The Center for Environmental Farming Systems (CEFS)²² has developed a model Community Supported Agriculture (CSA), which serves to educate, promote, and facilitate the consumer-farmer CSA model in North Carolina. Through this program, CEFS is working to develop a network of CSA’s across the state and to connect local farmers to companies and institutional food buyers.

Types(s) of GHG Benefit(s): Reduction in CO₂ emissions by reducing gasoline, diesel, and jet fuel use.

Ancillary Benefits and or Costs: Reduced transportation would also lead to reduced criteria and toxic air pollutants. Increased sales of local products would benefit the local economy.

Estimated GHG Savings and Cost per Ton CO₂e: The table below is based on a study that partially evaluated dynamic effects of shifting production location and transportation demand. It is not a full market simulation.

Variable	Data
Gallons of fuel annually saved Iowa/10% policy	8,800,000
Pounds CO ₂ saved	172,480,000
MMTCO ₂ e reduced from fuel savings	0.078
Iowa population 2003	2,944,062
North Carolina population 2003	7,036,927
Population adjusted NC MMTCO ₂ e savings	0.19
Costs per MTCO ₂ e	TBD

²¹ NCDOA, “Goodness Grows in North Carolina”, accessed at: www.ncagr.com/markets/gginc/ .

²² See www.cefs.ncsu.edu/organic.htm.

Data Sources, Methods and Assumptions: All data sources, methods and assumptions are based on an Iowa State University study,²³ and were scaled to North Carolina using state population adjustments. The study analyzed the feasibility and effects of shifting transportation distance and mode.

Key Uncertainties:

- Percent of food categories that can be shifted to locally grown
- Relative mix of food categories in NC compared to Iowa
- Travel distance of food under present (conventional) circumstances
- Cost of growing food locally vs. elsewhere (as determined by market)
- Incentive system required to make producer and consumer shifts viable

Estimation of Ancillary Benefits and Costs:

- **Benefits:** TBD.
- **Costs:** TBD.

Description of Feasibility Issues: North Carolina is a major production area for fruits and vegetables, producing over 25 major fruit and vegetable crops. However, a significant portion of the produce consumed in the state is imported from other states or other countries. There is significant potential for shifting of imported produce to locally grown fruits and vegetables.

Forestland Protection

Policy Description: Protection of 58,800 acres per year of North Carolina forestland cover over 14 years, starting in 2006 and ending in 2020, consistent with the current proposed DENR initiative to protect 1 million acres of natural land targeted primarily to forestland. This policy focuses on the use of implementation mechanisms targeted to lands at risk of conversion using growth neutral implementation that reduce net land clearing without affecting total residential or commercial starts.

BAU Policies/Programs: The state loses 58,800 acres of forest cover per year on average to permanent conversion of forest to developed land uses (2002 USDA Natural Resource Inventory (NRI)). Current activities by the state and private land trust community, including the Clean Water Management Trust Fund, reduce this trend to some extent below even higher levels that otherwise might result. As a result of continued losses of natural lands DENR recently began development of a statewide initiative to protect 1 million acres of natural land from conversion. This proposal is not yet adopted, and is the basis of this proposal.

²³ Richard Pirog et al, *Food, Fuel, and Freeways: An Iowa perspective on how far food travels, fuel usage, and greenhouse gas emissions*, Leopold Center for Sustainable Agriculture, Iowa State University, June 2001, <http://www.leopold.iastate.edu/pubs/staff/ppp/>.

Types(s) of GHG Benefit(s): Forestland protection GHG savings result from C sequestration from protection of biomass stocks, reduced CO2 emissions from avoided land clearing, and reduced petroleum use and related CO2 emissions from travel demand reductions (depending on the configuration of land protection programs).

Types of Ancillary Benefits and or Costs: Forestland protection and increased retention of forestland cover improves watershed function, wildlife habitat, air quality, travel needs, housing location efficiency, natural heritage, and economic opportunities on working lands.

Estimated GHG Savings and Cost per Ton CO2e:

Forest Land Protection	
Forest Savings	
Total DENR program acres saved over 14 years	1,000,000
Annual DENR program acres saved over 14 years	71,429
Annual acres forestland lost per year 1982-1997	58,800
Targetted annual acres forestland by DENR program 2006-2020	58,800
MTC per acre saved forest biomass (nonsoil)	73.96
MTC per acre forest soil saved	9.25
MTCO2e per acre saved forest (nonsoil)	270.694
MTCO2e per acre saved forest (soil)	33.837
MTCO2e saved per acre per year total	304.530
MTCO2e total acres saved per year total biomass and soil	17,906,381.64
MTCO2e credit for wood products & landfills	-3,311,248.09
MTCO2 credit from building materials substitution	-1,009,901.02
MTCO2 displaced electric power	-2,645,281.97
Annual GHG Forest Cover and Soils Savings MMTCO2e	10.94
Transportation Savings	
Annual acres saved over 14 years	58,800
Housing units affected (3 home per acre LC average)	43,881
Density increases resulting from land conservation	144.12%
VMT per household before	22,000
VMT per household after	20,900
Gallons fuel reduction per HH from land conservation	51
MTCO2e avoided per HH from land conservation/VMT annual	0.455267
MTCO2e avoided all HH from land conservation/VMT annual	19977.39
Annual GHG Transportation Savings MMTCO2e	0.02
Option Total Net GHG Savings MMTCO2e	10.96
Cost per acre forest retention standard (low scenario)	-\$2,000.00

Cost per acre permanent conservation easement (high scenario)	\$2,700.00
Annual Cost/MMTCO₂e 2006-2020 (low scenario)	-\$8.64
Annual Cost/MMTCO₂e 2006-2020 (high scenario)	\$3.02

Data Sources, Methods and Assumptions:

- Forestland carbon densities and acreage figures are provided by the USDA Forest Service FORCARB inventory system, based on state level Forest Inventory Assessments (FIA) by the USFS using a series of permanent sample plots. Statewide forest carbon levels average 73.96 metric tons per acre. Land use and land cover change data are provided by FORCARB as well as the USDA Natural Resource Inventory (NRI) based on state level collection of land cover data using a series of permanent sample plots. Statewide forest cover conversion to urban land uses averaged 58,800 acres per year from 1982-97. The disposition of harvested biomass is provided by the US Forest Service HARVCARB model. Energy displacement of wood products building materials is provided by the CORRIM model. Housing densities were calculated using the 1997 and 1999 American Housing Surveys of the US Department of Housing and Urban Development and Census Bureau. Average annual travel mileage and gasoline consumption for households was obtained from the US DOT survey data. Estimates of travel demand reductions were obtained from the Connecticut Climate Change Stakeholder Dialog and related transportation demand evaluations. The cost of land clearing (and the benefit of avoided land clearing) was provided by a NOAA Coastal Zone Management study at \$2,000 per acre. The cost of land protection mechanisms is provided by the North Carolina Clean Water Management Trust Fund program for permanent conservation easements.
- Quantification Methods:** A full life cycle net impact analysis was used, including impacts of the conversion of biomass to combustion or decay as a result of land clearing, minus the positive impacts of biomass recovery for harvested wood products storage and energy recapture. Potential transportation demand savings are included. The FORCARB carbon stock inventory system allows detailed measurement of carbon stocks prior to and after conversion for above and below ground biomass stocks. Soil carbon impacts were estimated with FORCARB soil carbon equations. The net carbon impacts of conversion of post harvest biomass to harvested wood products and energy recapture was estimated based on field study results from the HARVCARB model (for wood products and associated waste recovery for energy) and CORRIM model (for building materials substitution). Estimated fractions of harvested biomass solely for energy recapture are provided by the US Forest Service at a regional level. Energy displacement values are based on current NEMS modeling by CCS for the energy supply sector. Travel demand and petroleum use calculations were based on the differential impacts of conventional large lot development (typically associated with significant land clearing) versus location efficient housing (typically associated with conservation design or limited impact development that reduces land clearing). Costs were calculated as the positive cost of reducing land clearing through conservation easements or regulatory mechanisms, minus the

negative cost (the savings) associated with avoided land clearing. No discounting of benefits was used.

- **Key assumptions:** Implementation mechanisms are assumed to focus effectively on lands at risk of permanent conversion and use growth neutral mechanisms that do not result in movement of housing or commercial starts to areas outside the state that are not subject to the policy. As a result, it is assumed that reductions in average forestland cleared per new housing or commercial start do not reduce the number of building starts in the state (the same number of units are built on smaller lots or with higher rates of forest cover retention) but they do result in less land cleared per unit. On forested lots cleared for development, which average two acres for single family housing, two thirds of the acreage is typically cleared of forest cover and one quarter acre experiences subsurface disturbance and complete loss of soil carbon. Based on USDA Forest Service data, forest soils were estimated at maturity to hold about 50 percent as much carbon as above ground stocks (based on statewide average stand mix). Following conversion of forestland to developed uses, cleared acreages lose 25 percent of soil carbon and do not accumulate or lose additional biomass or soil carbon beyond that point. Biomass removed from cleared lands is assumed to be used commercially at the statewide average for harvested wood products and energy recapture. Cost calculations assumed a high cost pathway requiring permanent conservation easements (\$2,700 per acre based on from the Clean Water Management Trust Fund), and a low cost pathway assuming no net increased cost associated with tree retention standards that do not increase development costs. In both cases total costs were adjusted with the added benefit of \$2,000 per acre saved from avoided land clearing. No co-benefits were assumed.

Key Uncertainties:

- **Benefits:** The level of benefits is dependent primarily on the quality of implementation assumptions, such as the efficacy of programs targeted to lands at risk of conversion and use of growth neutral mechanisms that ensure net reductions in land clearing, as well as the programmatic feasibility of launching and funding a program as needed during the 2006-2020 time period. Otherwise, none of the major variables affecting biomass carbon dynamics are significantly uncertain over the range of potential variation due to issues with data sources, methods or technical assumptions.
- **Costs:** The cost of regulatory standards to increase forest cover retention during development is not well known, and can, theoretically, vary from zero (or negative) to the full cost of a permanent conservation easement. Conservation design, new urbanist, targeted infrastructure, and other location and site design approaches appear to perform equally as well if not better than conventional housing and commercial development in terms of costs and financial returns from development, so there is some reason to believe that cost neutral mechanisms are possible. The cost and efficacy of permanent conservation easements is well known.

Description of Ancillary Benefits and Costs:

- **Benefits:** TBD.
- **Costs:** TBD.

Description of Feasibility Issues: An in depth analysis of programmatic effectiveness and feasibility issues is beyond the scope of this analysis at this time, but within the scope of future planning and analysis.

Afforestation and Forestland Restoration

Policy Description: Active afforestation of 300,000 acres of former tobacco land over 14 years, or 21,429 acres per year starting in 2006, consistent with currently proposed state initiatives. Ensure incremental afforestation at these levels above business as usual using active management and protection techniques as appropriate for site and geography.

BAU Policies/Programs: North Carolina has a number of state and federal cost share and technical assistance programs to assist private nonindustrial land owners with afforestation that are administered through the Division of Forestry and State Extension Service. Current market incentives drive high levels of reforestation and afforestation on industrial lands and many nonindustrial lands. Afforestation levels are typically lower on nonindustrial lands due to risk, cost, and lack of information and assistance. Natural afforestation occurs at significant levels on farmlands that are withdrawn from production, but may face significant ecological and development risk if not adequately protected and managed.

Types(s) of GHG Benefit(s): GHG savings result from C sequestration.

Types of Ancillary Benefits and or Costs: Forestland cover improves watershed function, wildlife habitat, air quality, travel needs, housing location efficiency, natural heritage, and economic opportunities on working lands.

Estimated GHG Savings and Cost per Ton CO₂e:

Afforestation of former tobacco lands	
Acres over 14 years	300,000
Annual acres afforested	21,429
Average stand age 2006-2050	35
MTC per acre biomass nonsoil age 35	33.67
MTCO ₂ e per acre biomass nonsoil age 35	123.23
Option Total GHG Savings 2006-2020 MMTCO₂e	2.64
Cost per acre initial treatment	\$120.00
Cost per Ton CO₂e 2006-2020 + 2050	\$0.97

Data Sources, Methods and Assumptions:

- **Data Sources:** Tree growth rates provided by the USDA Forest Service, Richard Birdsey, 1996. An average figure at age 35 was calculated using a simple average of all nine stand types provided by the USFS based on earliest age of average harvest by the North Carolina Agricultural Extension Service. Acreage figures and per acre costs were provided by the North Carolina Agricultural Extension Service. Cost figures are for a one-time treatment of land with no additional management.
- **Quantification Methods:** Biomass carbon was calculated over 35 years to represent one full generation of tree growth (likely to underestimate some stand types). The benefits of growth in years after the end of the project period (2020) were added and levelized to calculate an annual carbon benefit. The starting condition of the land is assumed to be fallow farmland. No risk is assumed for stand establishment, growth or conversion to nonforest cover. No discounting of benefits was used.
- **Key assumptions:** Stands were assumed to mature at 35 years and start with no above ground carbon. Soil carbon levels were assumed to have no change over the period. No risks were assumed. Costs for all establishment and stand types were assumed to be the same as the level required for establishment of a pine plantation.

Key Uncertainties:

- **Benefits:** Risks of land conversion, drought and other damage are potentially high for some lands. The period of biomass growth following 2020 is driven by ecological and market conditions, as well as arbitrary assumptions about the end of the quantification period. If discounting of benefits is not used, these variables have significant impacts on project performance.
- **Costs:** Risk management may involve added costs that require further study. In the extreme this might include permanent conservation easements, for instance, and would raise costs per acre significantly.

Description of Ancillary Benefits and Costs:

- **Benefits:** None at this time.
- **Costs:** None at this time.

Description of Feasibility Issues: An in depth analysis of programmatic effectiveness and feasibility issues is beyond the scope of this analysis at this time, but within the scope of future planning and analysis.

Chapter 2 - Energy Supply and Demand

Overview of Energy Supply and Demand Options

Four energy supply policy options are analyzed below using the National Energy Modeling System (NEMS) from the US Energy Information Administration. Some of these options incorporate energy efficiency provisions which are examined by modeling the effects of demand reduction scenarios.

Any analysis of state-level policies using NEMS should be weighed carefully. NEMS is a national model that consists of 13 regions. State policies cannot be implemented explicitly within NEMS, and the state-specific impacts cannot be known explicitly. Although we have crafted a methodology that approximates the impact of a policy implemented at the state level, the methodology is not perfect. Because the absolute levels of change that are appropriate at the state level may be small at the regional level, the results of those small changes may not be entirely accurate. The larger the policy – the more demand reduction or the more renewables or both – the more confidence we have in the result. Because NEMS is an optimization model, small changes can lead to unrealistic responses. For example, a small reduction in demand can change the investment decision for new capacity within the model because the model is aware of that small change. In reality, independent actors in the electricity market making investment decisions may not be able to detect a small change in demand and, even if they did, may not have the certainty to act on that change; these actors are unlikely to alter investment decisions the way the model would. On the other hand, real actors would be more likely to be aware of and act upon a larger change in demand.

The results of this analysis are preliminary and should not be considered final numbers on which to base policy decisions. The NEMS reference case scenario is the EIA's best guess at the forecast of activities in the electricity market for the Southeastern Electric Reliability Council (SERC) region containing North Carolina and for the United States as a whole. In developing this reference case, the EIA consults experts who believe that the market will follow a certain path, and then the EIA builds those assumptions into the model.

For example, the EIA assumes that there will be no new generating capacity in the SERC region from 2007 through 2014. All growth in demand during this period is satisfied either by imports from other regions or by existing capacity within the region. All of the scenarios, which are based on the reference case, show little reductions (and some small increases) in CO₂ emissions before 2015 because many of the resulting changes are taking place outside the region, as reflected through reductions in imports. Scenarios that are only demand reductions show either increased generation of fossil fuels (state facilities target) or larger decreases in natural gas generation compared to coal (PBF scenarios) in the region. Even though generation from fossil fuels declines slightly in both of the PBF cases, the change in how units are operated (e.g. more units are in cycling mode in which they burn fuel but do not generate electricity) leads to a slight

increase in the consumption of fossil fuels and therefore CO₂ emissions from 2007 through 2014.

After 2014, the state facilities target and the PBF 2 mils scenarios both lead to reductions in generation from coal and to increases in generation from natural gas and oil units. The net result is a decline in CO₂ emissions, but an increase in cost because natural gas units are more expensive to build and operate than coal. The PBF 5 mils scenario results in a decrease in generation from coal and natural gas units and an increase in generation from oil units; the demand reduction is sufficient to obviate the need for frequently run units like coal steam and natural gas combined cycle. But the reserve margin must be maintained, so more lower-cost capacity – oil-fired combustion turbines – is installed. The result is a decrease in CO₂ emissions and costs.

Prior to 2015, scenarios that force renewables into the region lead to less fossil-based generation from existing capacity within SERC and to corresponding reductions in CO₂ emissions. These scenarios, after 2015, lead to a reduction in new fossil fuel capacity compared to the reference case, which also leads to emission reductions.

The reference case projection for the state of North Carolina, which was developed independently from the reference case in NEMS, assumes that new coal-fired units will be constructed in North Carolina prior to 2015 based on recent announcements by major utilities within the state. The NEMS reference case precedes this information, and the time available for this analysis precluded an update. If the NEMS reference case were updated to reflect the addition of new coal capacity before 2015, policy runs would result in lower emissions as well as a lower cost per ton for those emissions. By using the current NEMS reference case, we have provided a conservative estimate for emission reductions and costs in North Carolina.

Renewable Portfolio Standard

Policy Description: A renewable portfolio standard (RPS) is a requirement that load serving entities (LSEs) must supply a certain percentage of electricity from renewable energy sources. For example, an RPS of 5% would mean that for every 100 kWh that an LSE supplies to end users, 5 kWh must be generated from renewable resources. An RPS differs from an Environmental Portfolio Standard (EPS) in that an RPS is a requirement specifically for renewables, while an EPS is broader and includes energy efficiency. LSEs can meet their requirements by purchasing or generating renewable-based electricity or by purchasing renewable energy credits (RECs). RECs are tradable credits that are part of an RPS policy. RECs are created for every kWh of eligible and verified renewable electricity produced. Anyone can build an eligible renewable facility and earn RECs for the electricity that is generated. Anyone with RECs can sell them to a utility that needs to meet its RPS requirement. In this way, utilities themselves do not need to build and operate renewable generating facilities. By giving utilities the flexibility to purchase RECs, the market in these credits will provide an incentive to companies that are best able to generate renewable energy.

The RPS scenario considered in this report was developed by Appalachian State University and assumes a mix of renewables that includes biomass, wind, landfill gas, hydro, solar thermal, and solar PV. The RPS requirement is assumed to ramp up between 0.5% in 2006 and 10% in 2015 and to remain at 10%.

BAU Policies/Programs: No RPS program is in operation in North Carolina. However, the GreenPower program is in operation.²⁴ This program provides the option to consumers to purchase green power, but it is not a requirement to generate renewables as an RPS would be.

Types(s) of GHG Benefit(s): By creating a substantial market in renewable generation, an EPS can significantly reduce fossil fuel use in power generation and thus reduce GHG emissions.

Types of Ancillary Benefits and or Costs: The shift from fossil fuel generation as a result of an RPS will lead to reductions in criteria air pollutants and, consequently, health costs associated with those pollutants. While much of the RPS requirement will come from low-cost renewables such as wind and biomass, meeting the requirement leads to a moderate increase in direct costs to LSEs implementing the RPS policy and a small increase in overall electricity system cost for the SERC region. At the same time, though, investment in new technologies resulting from the RPS can spur economic development in North Carolina if in-state capital/labor/fuel replaces out-of-state fuel (a likely outcome).

²⁴ GreenPower is a voluntary program that adds green electricity generation in North Carolina. For example, residential electricity customers can opt to pay an additional \$4 per month for a block of 100 kWh of green power. For more information, see: <http://www.ncgreenpower.org>

Estimated GHG Savings and Cost per Ton CO2e:

	MMtCO2				
	2005	2010	2015	2020	2025
Reference	76	81	90	100	110
RPS	76	81	89	92	94
Reduction	0	0.0	1.4	7.8	16.2
<i>Percent Reduction</i>	<i>0.0%</i>	<i>0.0%</i>	<i>1.5%</i>	<i>7.8%</i>	<i>14.7%</i>

2005 = 2005, 2010 = average of 2006 - 2010, 2015 = average of 2011 - 2015 and so on

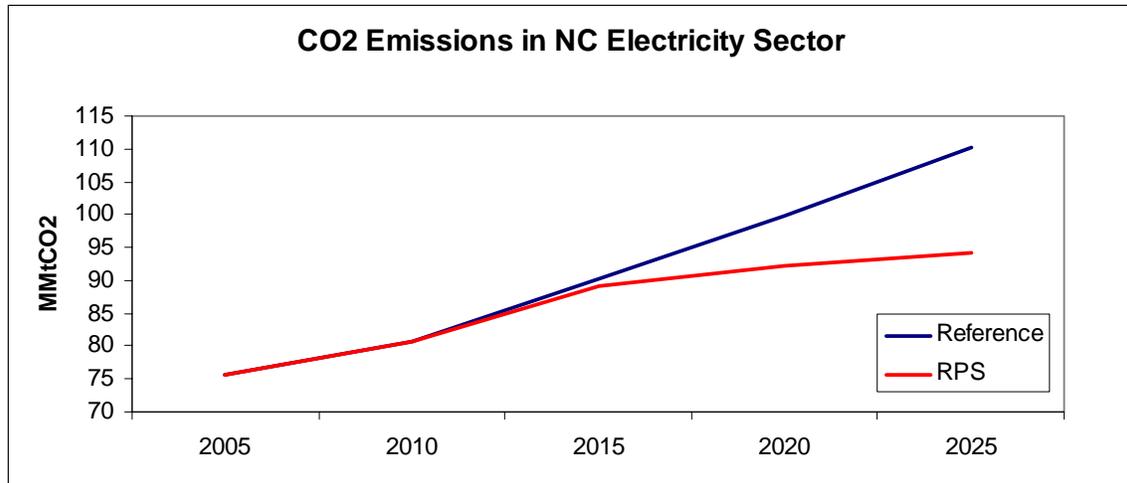
	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)
	Cumulative CO2 Reduction (MMtCO2) to 2025	Cumulative NC CO2 Emissions (MMtCO2) to 2025 with Policies	Percent Reduction	Direct Policy Cost (\$ NPV billions)	Direct Policy Benefits (\$ NPV billions)	Net Direct Policy Cost (\$ NPV billions)	\$/ton CO2 (Direct Cost)	SERC System Incremental Cost (\$ NPV billions)	System + Direct Cost (\$ NPV billions)	\$/ton CO2 (SERC System Cost)
RPS	126.6	1706	6.9%	\$0.88	\$0.00	\$0.88	\$7.0	\$0.61	\$1.49	\$11.8
NOTES:	CO2 reductions as a result of policy	Reference case emissions (1833 MMtCO2) - (a)	(a) / (b)	Direct incremental cost of policy out to 2025 ¹	Direct incremental benefits of policy out to 2025 ²	(d) - (e)	(f) * 1000 / (a)	Difference between policy and reference SERC region system cost out to 2025 ³	(d) + (h)	(i) * 1000 / (a)

¹ For example, renewable costs are total costs of renewables - total cost of equivalent amount of new fossil capacity. Direct Policy Costs are seen by the implementor of the policy

² For example, difference between the cost of efficiency and either the cost of generation (EPS) or the cost to the end user (Government Target). Direct Policy Benefits are seen by the implementor of the policy

³ Implicit in Incremental System Costs are Policy Benefits. Incremental System Costs represent the impact of the policy on the total cost of the electricity system within SERC, but do not reflect the Direct Policy Cost

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2005 = 2005; 2010 = average of 2006 – 2010; 2015 = average of 2011

Data Sources, Methods and Assumptions: Most data for the electricity modeling done in this analysis comes from the US Energy Information Administration (EIA) and can be found within the National Energy Modeling System (NEMS). Data in NEMS includes representation of the existing generation, transmission and distribution system down to the unit level. NEMS also includes data that characterizes new plants that the model can choose to build to meet projected demand growth. EIA publishes *Assumptions to the Annual Energy Outlook* that details key assumptions in the current version of the model.²⁵ EIA also publishes NEMS model documentation.²⁶

The specific mix and levels of renewable capacity in RPS policy were developed using the North Carolina Energy Economic Model written by Skip Laitner for the North Carolina State Energy Office and maintained at Appalachian State University. The RPS policy analyzed here is consistent with the RPS policy being analyzed by Appalachian State University to determine the indirect economic impact in North Carolina. All renewable plant characteristics were based on new plants defined within the NEMS model.

The RPS was analyzed by forcing the NEMS model to build renewable plants as defined by the RPS policy. Total system costs, carbon dioxide emissions, and other outputs were compared with a reference case NEMS run. Because the NEMS model is a national model with multi-state regions (North Carolina is within the Southeastern Electric Reliability Council or SERC), the policy was implemented within the SERC region at a level for North Carolina. We make the assumption that the change in outputs in the entire region is attributed wholly to the policy in North Carolina. This assumption is reasonable given that the electricity market operates at a regional and even inter-regional level. Although we can collect data within state bounds, any change in the electricity system within a given state will reverberate within the surrounding region and beyond.

²⁵ The document can be found here: [http://www.eia.doe.gov/oiaf/aeo/assumption/pdf/0554\(2005\).pdf](http://www.eia.doe.gov/oiaf/aeo/assumption/pdf/0554(2005).pdf)

²⁶ NEMS documentation can be found here: [http://www.eia.doe.gov/oiaf/aeo/overview/pdf/0581\(2003\).pdf](http://www.eia.doe.gov/oiaf/aeo/overview/pdf/0581(2003).pdf)

For the direct policy costs, we analyzed the RPS from the perspective of utilities implementing the policy. These costs are the incremental costs incurred by building renewables rather than the average mix of generation in the reference case plus the cost of investing in energy efficiency (the incremental cost of efficient rather than typical equipment).

The system cost, which is an output of the NEMS model, represents the increment in the total cost of the system (including capital, operating and maintenance, fuel, transmission and distribution) that results from the EPS. But the NEMS output does not include the direct policy cost, so we add it to the system cost to approximate the full cost to society.

One of the key assumptions of the RPS analysis is that higher cost renewables, such as solar thermal and solar photovoltaic, would be built to satisfy part of the RPS requirement. This assumption is based on the RPS containing a specific provisions requiring minimum levels of solar or other high-cost, but socially important, renewables. ASU made key assumptions regarding the mix of other renewables. An RPS may lead to a different mix than the mix assumed here. One source may be dominant under an RPS, particularly if additional policies are enacted that encourage one over the others. For example, if subsidies to biomass were put into place, then the biomass share would likely increase.

The last key assumption is that we forced NEMS to build enough capacity such that it would generate enough electricity to meet the RPS requirement based on standard capacity factors. Once the capacity is in the system, NEMS will choose to operate that capacity in a way to minimize costs. If the renewable plant is run more or less than was assumed in developing the capacity levels, then it would generate more or less electricity than what is needed for the RPS.

Key Uncertainties: As with any assessment of the future, the RPS analysis has many uncertainties. Key uncertainties are, first, related directly to the key assumptions. If those assumptions are incorrect, then the results would change. Other key uncertainties are the ability of the NEMS model to give credible results for the SERC region and for the resulting changes in the SERC region to be fully attributable to policies implemented in North Carolina. Other uncertainties are the forecast of the price of fossil fuels, the cost, availability and operating characteristics of new power plants in the future, and the growth in the demand for electricity.

Description of Ancillary Benefits and Costs: The RPS policy analyzed here would result in reductions of criteria air pollutants as follows:

SO₂: 789,000 tons (cumulative through 2025) or 41,470 tons (average per year)

NO_x : 152,000 tons (cumulative through 2025) or 8,000 tons (average per year)

Mercury: 1.7 tons (cumulative through 2025) or 193 pounds (average per year)

Most reductions would occur later in the period, between 2015 and 2025.

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The RPS results in a net 0.30% increase in overall electricity system costs (on a NPV basis) compared to the reference case. Although the RPS leads to a net increase in costs, the change in the distribution of those costs should lead to more economic development in the state by shifting resources that were going to purchase fuel to funding North Carolina jobs and businesses. The RPS results in a \$1.74 billion (NPV) increase in capital expenditures in the electricity system, resulting in new engineering and construction jobs and business for North Carolina suppliers of power plant equipment. Operating and maintenance expenses increase by \$0.46 billion (NPV), translating into North Carolina jobs. Purchases of fuel, much of which comes from out of state, decrease by \$0.63 billion (NPV). The EPS also leads to \$0.10 billion (NPV) less in transmission costs, but \$0.03 billion more in distribution costs.

Description of Feasibility Issues: North Carolina has more than enough renewable resources to meet the EPS, and verification of renewable generation is quite feasible and easy to administer by the state.

Environmental Portfolio Standard

Policy Description: An environmental portfolio standard (EPS) is a requirement that load serving entities (LSEs) must supply a certain percentage of electricity from environmentally friendly sources. For example, an EPS of 5% would mean that for every 100 kWh that an LSE supplies to end users, 5 kWh must be from environmentally friendly sources. An EPS differs from a Renewable Portfolio Standard (RPS) in that an EPS gives the added option of meeting the requirement by means of “negawatts” generated through verified energy efficiency projects in addition to renewable generation. If a large industrial customer with a current demand of 35,000 MWh per year invests in energy efficiency that reduces demand by 20% or 7,000 MWh, and this investment and reduction are verified by an independent auditor, then the customer would have 7,000 MWh of clean energy credits to sell to an LSE. LSEs can meet their requirements by purchasing or generating environmentally friendly electricity or by purchasing clean energy credits. By giving LSEs the flexibility to purchase clean energy credits, a market in these credits will emerge that will provide an incentive to companies that are best able to generate clean energy, either through energy efficiency or renewables.

The EPS scenario examined in this report has a requirement of 5% clean energy by 2010, 10% by 2015, and 15% by 2020. The scenario assumes that only a certain level of energy efficiency, despite the low or even negative cost, will be used to fulfill the EPS requirements simply because of the transaction costs associated with verifying the reductions. The amount of energy efficiency was derived from *Powering the South, A Clean and Affordable Energy Plan* (2002), written by the Renewable Energy Policy Project and Synapse Energy, which estimates that North Carolina can reduce demand by 14% in 2010 and 23% in 2020 at an average cost of 2.6 cents/kWh. We assumed that the energy efficiency contribution to the EPS would come only from the industrial and commercial sectors, which have lower transaction costs for verification of energy efficiency projects than the residential sector. We also assumed that $\frac{3}{4}$ of the industrial

sector reduction and 1/2 of the commercial sector reduction from *Powering the South* could be applied toward the EPS. This level of energy efficiency amounted to approximately 1/5th of the EPS requirement. The remainder of the EPS was fulfilled by the maximum potential of landfill gas and roughly equal shares of biomass, wind, and hydro.

BAU Policies/Programs: No EPS program is in operation in North Carolina.

Types(s) of GHG Benefit(s): By creating a substantial market in energy efficiency and renewable generation, an EPS can significantly reduce fossil fuel use in power generation and thus reduce GHG emissions.

Types of Ancillary Benefits and or Costs: Reductions in overall energy consumption and the shift from fossil fuel generation as a result of an EPS will lead to reductions in criteria air pollutants and, consequently, health costs associated with those pollutants. While much of the EPS requirement will come from zero or low-cost (even negative cost) energy efficiency and low-cost renewables such as wind and biomass, meeting the requirement leads to a moderate increase in direct costs to LSEs implementing the EPS policy and a small increase in overall electricity system cost for the SERC region. At the same time, though, investment in new technologies resulting from the EPS can spur economic development in North Carolina if in-state capital/labor/fuel replaces out-of-state fuel (a likely outcome).

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Estimated GHG Savings and Cost per Ton CO₂e:

	MMtCO ₂				
	2005	2010	2015	2020	2025
Reference	76	81	90	100	110
EPS	76	81	89	94	99
Reduction	0	-0.1	1.6	5.4	11.5
<i>Percent Reduction</i>	<i>0.0%</i>	<i>-0.1%</i>	<i>1.7%</i>	<i>5.4%</i>	<i>10.4%</i>

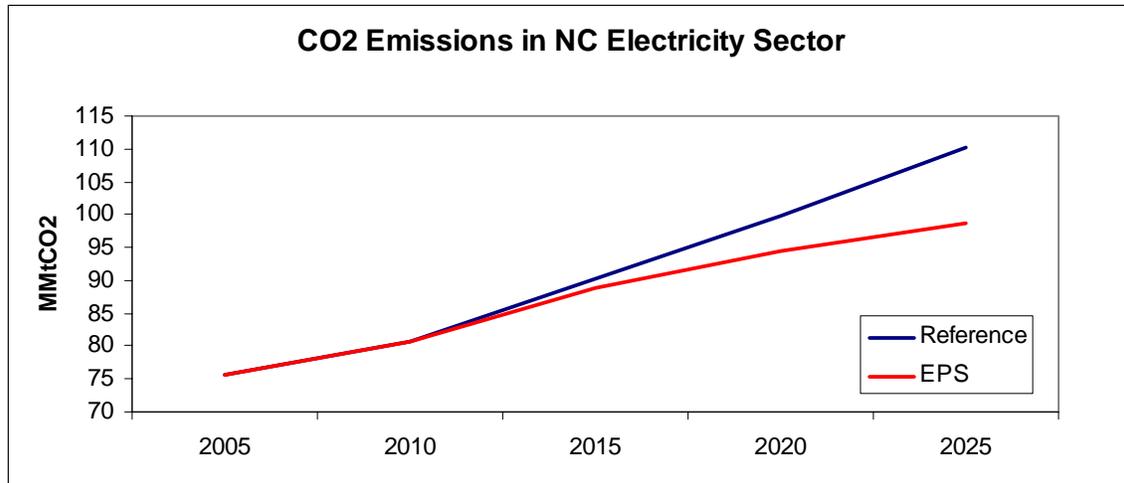
2005 = 2005, 2010 = average of 2006 - 2010, 2015 = average of 2011 - 2015 and so on

	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)
	Cumulative CO ₂ Reduction (MMtCO ₂) to 2025	Cumulative NC CO ₂ Emissions (MMtCO ₂) to 2025 with Policies	Percent Reduction	Direct Policy Cost (\$ NPV billions)	Direct Policy Benefits (\$ NPV billions)	Net Direct Policy Cost (\$ NPV billions)	\$/ton CO ₂ (Direct Cost)	SERC System Incremental Cost (\$ NPV billions)	System + Direct Cost (\$ NPV billions)	\$/ton CO ₂ (SERC System Cost)
EPS	91.8	1741	5.0%	\$1.01	\$0.71	\$0.30	\$3.2	(\$0.81)	\$0.20	\$2.2
NOTES:	CO ₂ reductions as a result of policy	Reference case emissions (1833 MMtCO ₂) - (a)	(a) / (b)	Direct incremental cost of policy out to 2025 ¹	Direct incremental benefits of policy out to 2025 ²	(d) - (e)	(f) * 1000 / (a)	Difference between policy and reference SERC region system cost out to 2025 ³	(d) + (h)	(i) * 1000 / (a)

¹ For example, renewable costs are total costs of renewables - total cost of equivalent amount of new fossil capacity. Direct Policy Costs are seen by the implementor of the policy

² For example, difference between the cost of efficiency and either the cost of generation (EPS) or the cost to the end user (Government Target). Direct Policy Benefits are seen by the implementor of the policy

³ Implicit in Incremental System Costs are Policy Benefits. Incremental System Costs represent the impact of the policy on the total cost of the electricity system within SERC, but do not reflect the Direct Policy Cost



2005 = 2005; 2010 = average of 2006 – 2010; 2015 = average of 2011

Data Sources, Methods and Assumptions: Most data for the electricity modeling done in this analysis comes from the US Energy Information Administration (EIA) and can be found within the National Energy Modeling System (NEMS). Data in NEMS includes representation of the existing generation, transmission and distribution system down to the unit level. NEMS also includes data that characterizes new plants that the model can choose to build to meet projected demand growth. EIA publishes *Assumptions to the Annual Energy Outlook* that details key assumptions in the current version of the model.²⁷ EIA also publishes NEMS model documentation.²⁸

The specific levels of renewable capacity and energy efficiency that make up the EPS policy were developed using a combination of sources. For energy efficiency, the level of energy efficiency investment was derived from *Powering the South*.²⁹ The potential for landfill gas was developed using projections derived from the EPA Landfill Methane Outreach Program (LMOP) database. The levels of biomass, wind and hydro were assumed to be roughly equal and sufficient to fulfill the EPS requirement. All renewable plant characteristics were based on new plants defined within the NEMS model.

The EPS was analyzed by forcing the NEMS model to build renewable plants as defined by the EPS policy and by lowering the demand for electricity in the commercial and industrial sectors by an amount equal to the level of energy efficiency assumed by the EPS. Total system costs, carbon dioxide emissions, and other outputs were compared with a reference case NEMS run. Because the NEMS model is a national model with multi-state regions (North Carolina is within the Southeastern Electric Reliability Council or SERC), the policy was implemented within the SERC region at a level for North Carolina. We make the assumption that the change in outputs in the entire region is attributed wholly to the policy in North Carolina. This assumption is reasonable given that the electricity market operates at a regional and even inter-regional level. Although

²⁷ The document can be found here: [http://www.eia.doe.gov/oiaf/aeo/assumption/pdf/0554\(2005\).pdf](http://www.eia.doe.gov/oiaf/aeo/assumption/pdf/0554(2005).pdf)

²⁸ NEMS documentation can be found here: [http://www.eia.doe.gov/oiaf/aeo/overview/pdf/0581\(2003\).pdf](http://www.eia.doe.gov/oiaf/aeo/overview/pdf/0581(2003).pdf)

²⁹ Powering the South can be found here: <http://www.poweringthesouth.org/report/>

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we can collect data within state bounds, any change in the electricity system within a given state will reverberate within the surrounding region and beyond.

For the direct policy costs and benefits, we analyzed the EPS from the perspective of utilities implementing the policy. These costs are the incremental costs incurred by building renewables rather than the average mix of generation in the reference case plus the cost of investing in energy efficiency (the incremental cost of efficient rather than typical equipment). The direct policy benefits are the savings of the cost of generation resulting from energy efficiency.

The system cost, which is an output of the NEMS model, represents the increment in the total cost of the system (including capital, operating and maintenance, fuel, transmission and distribution) that results from the EPS. But the NEMS output does not include the direct policy cost, so we add it to the system cost to approximate the full cost to society. We do not need to add the direct policy benefits because those are already reflected in incremental system cost that comes out of NEMS.

Key assumptions of the EPS analysis are that only a portion of the available energy efficiency as characterized in *Powering the South* would be used to satisfy the EPS requirement under the assumption that the transaction costs associated with verifying energy reductions would limit the amount of energy reduction. Another key assumption is that biomass, wind and hydro would be used in equal shares. One source may be dominant if an EPS were actually implemented, particularly if additional policies are enacted that encourage one over the others. For example, if subsidies to biomass were put into place, then the biomass share would likely increase. The last key assumption is that we forced NEMS to build enough capacity such that it would generate enough electricity to meet the EPS requirement based on standard capacity factors. Once the capacity is in the system, NEMS will choose to operate that capacity in a way to minimize costs. Because demand reductions are also part of the EPS, if a renewable plant that was built as a result of the EPS is on the margin in the dispatch order, it will not run because of the demand reduction. Similarly, if the renewable plant is able to run more hours than was assumed in developing the capacity levels, then it would generate more electricity than what is needed to meet the RPS. The actual output of the renewable plants in practice may not equal the requirement of the RPS.

Key Uncertainties: As with any assessment of the future, the EPS analysis has many uncertainties. Key uncertainties are, first, related directly to the key assumptions. If those assumptions are incorrect, then the results would change. Other key uncertainties are the ability of the NEMS model to give credible results for the SERC region and for the resulting changes in the SERC region to be fully attributable to policies implemented in North Carolina. Other uncertainties are the forecast of the price of fossil fuels, the cost, availability and operating characteristics of new power plants in the future, and the growth in the demand for electricity.

Description of Ancillary Benefits and Costs: The EPS policy analyzed here would result in reductions of criteria air pollutants as follows:

- SO₂: 468,000 tons (cumulative through 2025) or 24,600 tons (average per year)
- NO_x : 24,400 tons (cumulative through 2025) or 1,290 tons (average per year)
- Mercury: 0.18 tons (cumulative through 2025) or 20 pounds (average per year)

Most reductions would occur later in the period, between 2015 and 2025.

The EPS results in a net 0.04% increase in overall electricity system costs (on a NPV basis) compared to the reference case. Although the EPS leads to a net increase in costs, the change in the distribution of those costs should lead to more economic development in the state by shifting resources that were going to purchase fuel to funding North Carolina jobs and businesses. The EPS results in a \$1.16 billion (NPV) increase in capital expenditures in the electricity system, resulting in new engineering and construction jobs and business for North Carolina suppliers of power plant equipment. Operating and maintenance expenses increase by \$0.15 billion (NPV), translating into North Carolina jobs. The EPS causes \$0.49 billion in purchases of energy efficient equipment. Purchases of fuel, much of which comes from out of state, decrease by \$1.29 billion (NPV). The EPS also leads to \$0.32 billion (NPV) less in transmission and distribution costs.

Description of Feasibility Issues: The only significant feasibility issue is the process of verifying energy reductions to be used to satisfy the EPS requirement. North Carolina has more than enough renewable resources to meet the EPS, and verification of renewable generation is quite feasible and easy to administer by the state.

Public Benefit Fund

Policy Description: A public benefit fund (PBF) is a state fund dedicated to support energy efficiency (EE) and renewable energy (RE). To date, nineteen states have implemented PBF programs. A small charge rate, typically in the 2 to 5 mils per kWh range, is applied to electricity sales in the state and collected by the PBF manager. Funds are typically used to support EE and RE in a number of ways, such as through public education, R&D, demonstration projects, direct grants/buydowns/tax credits to subsidize advanced technologies, and low-interest revolving loans. Funding goes to the residential, commercial and industrial sectors. Fund managers decide which technologies to support based on criteria such as GHG reduction potential, cost-effectiveness, co-benefits, etc.

The two PBF scenarios analyzed here differ by assumed charge rates. One scenario examines the impact of a fund based on a 2 mil charge rate, and the other assumes a 5 mil charge.

BAU Policies/Programs: No PBF program is in operation in North Carolina.

CCS NC Policy Description Template

Types(s) of GHG Benefit(s): By spurring investment in energy efficient technologies and small-scale renewable generators, PBF programs reduce the need for generation from fossil fuel plants, which can lead to a significant reduction in GHG emissions.

Types of Ancillary Benefits and or Costs: Reductions in overall energy consumption and the shift from fossil fuel generation as a result of a PBF will lead to reductions in criteria air pollutants and, consequently, health costs associated with those pollutants. Much of the investment made by the PBF will go into zero or low-cost (even negative cost) energy efficiency and small-scale renewables, and the PBF program will more than pay for itself through cost-effective investments. Nevertheless, the impact on the larger electricity system of the PBF program can lead to a small increase in overall electricity system cost for the SERC region (see modeling discussion below).

Estimated GHG Savings and Cost per Ton CO2e:

	MMtCO2				
	2005	2010	2015	2020	2025
Reference	76	81	90	100	110
PBF (2 mils)	76	81	91	96	101
Reduction	0	-0.4	-0.8	4.4	9.5
<i>Percent Reduction</i>	<i>0.0%</i>	<i>-0.5%</i>	<i>-0.9%</i>	<i>4.4%</i>	<i>8.6%</i>
PBF (5 mils)	76	81	91	97	102
Reduction	0	-0.3	-0.3	2.8	8.6
<i>Percent Reduction</i>	<i>0.0%</i>	<i>-0.3%</i>	<i>-0.3%</i>	<i>2.8%</i>	<i>7.8%</i>

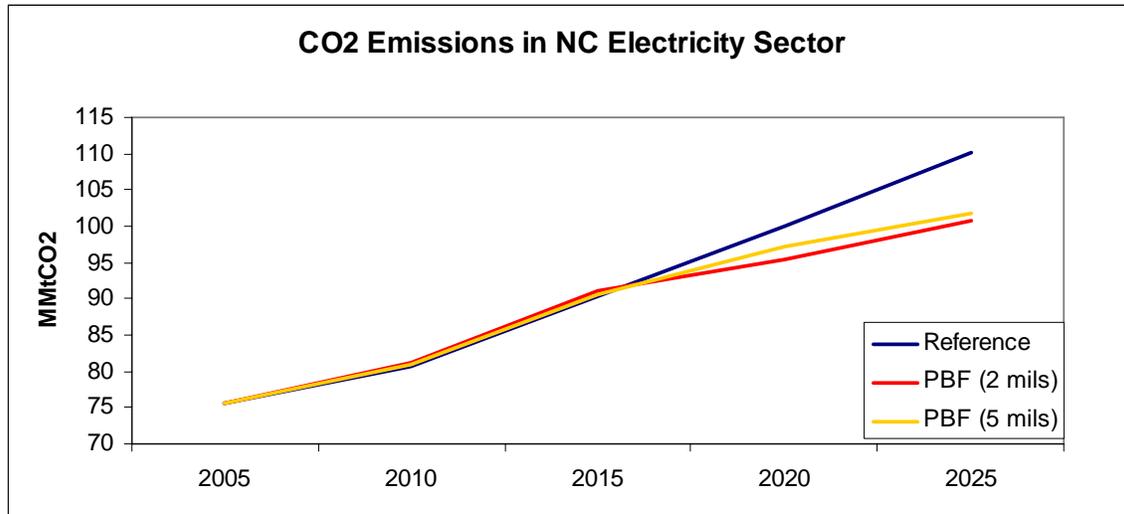
2005 = 2005, 2010 = average of 2006 - 2010, 2015 = average of 2011 - 2015 and so on

	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)
	Cumulative CO2 Reduction (MMtCO2) to 2025	Cumulative NC CO2 Emissions (MMtCO2) to 2025 with Policies	Percent Reduction	Direct Policy Cost (\$ NPV billions)	Direct Policy Benefits (\$ NPV billions)	Net Direct Policy Cost (\$ NPV billions)	\$/ton CO2 (Direct Cost)	SERC System Incremental Cost (\$ NPV billions)	System + Direct Cost (\$ NPV billions)	\$/ton CO2 (SERC System Cost)
PBF (2 mils)	62.7	1770	3.4%	\$0.15	\$0.49	(\$0.33)	(\$5.3)	\$0.34	\$0.49	\$7.8
PBF (5 mils)	53.8	1779	2.9%	\$0.49	\$1.29	(\$0.80)	(\$14.9)	(\$0.54)	(\$0.05)	(\$1.0)
NOTES:	CO2 reductions as a result of policy	Reference case emissions (1833 MMtCO2) - (a)	(a) / (b)	Direct incremental cost of policy out to 2025 ¹	Direct incremental benefits of policy out to 2025 ²	(d) - (e)	(f) * 1000 / (a)	Difference between policy and reference SERC region system cost out to 2025 ³	(d) + (h)	(i) * 1000 / (a)

¹ For example, renewable costs are total costs of renewables - total cost of equivalent amount of new fossil capacity. Direct Policy Costs are seen by the implementor of the policy

² For example, difference between the cost of efficiency and either the cost of generation (EPS) or the cost to the end user (Government Target). Direct Policy Benefits are seen by the implementor of the policy

³ Implicit in Incremental System Costs are Policy Benefits. Incremental System Costs represent the impact of the policy on the total cost of the electricity system within SERC, but do not reflect the Direct Policy Cost



2005 = 2005; 2010 = average of 2006 – 2010; 2015 = average of 2011

Data Sources, Methods and Assumptions: Most data for the electricity modeling done in this analysis comes from the US Energy Information Administration (EIA) and can be found within the National Energy Modeling System (NEMS). Data in NEMS includes representation of the existing generation, transmission and distribution system down to the unit level. NEMS also includes data that characterizes new plants that the model can choose to build to meet projected demand growth. EIA publishes *Assumptions to the Annual Energy Outlook* that details key assumptions in the current version of the model.³⁰ EIA also publishes NEMS model documentation.³¹

The specific levels of energy efficiency and renewables achieved as a result of the PBF policy were developed using the North Carolina Energy Economic Model written by Skip Laitner for the North Carolina State Energy Office and maintained at Appalachian State University. The PBF policy analyzed here is consistent with the PBF policy being analyzed by Appalachian State University to determine the indirect economic impact in North Carolina. A small amount of renewable generation is part of the PBF policy, but since this capacity is assumed to be owned and operated by residential, commercial and industrial electricity customers, it was modeled within NEMS as a demand reduction.

The PBF was analyzed by lowering the demand for electricity in the residential, commercial and industrial sectors by an amount equal to the level of energy efficiency investment assumed by the PBF. Total system costs, carbon dioxide emissions, and other outputs were compared with the NEMS reference case. Because the NEMS model is a national model with multi-state regions (North Carolina is within the Southeastern Electric Reliability Council or SERC), the policy was implemented within the SERC region at a level for North Carolina. We make the assumption that the change in outputs in the entire region is attributed wholly to the policy in North Carolina. This assumption is reasonable given that the electricity market operates at a regional and even inter-regional level. Although we can collect data within state bounds, any change in the

³⁰ The document can be found here: [http://www.eia.doe.gov/oiaf/aeo/assumption/pdf/0554\(2005\).pdf](http://www.eia.doe.gov/oiaf/aeo/assumption/pdf/0554(2005).pdf)

³¹ NEMS documentation can be found here: [http://www.eia.doe.gov/oiaf/aeo/overview/pdf/0581\(2003\).pdf](http://www.eia.doe.gov/oiaf/aeo/overview/pdf/0581(2003).pdf)

electricity system within a given state will reverberate within the surrounding region and beyond.

For the direct policy costs and benefits, the PBF was analyzed from the perspective of the PBF fund administrators and electricity customers participating in the PBF program. These costs are the total costs incurred by ratepayers who must contribute to the PBF program and the incremental private investment (the additional cost to the customer of energy efficient equipment rather than typical equipment) of the customers who participate. The direct policy benefits are the cost savings to PBF participants associated with avoiding the purchase of electricity resulting from energy efficiency investments.

The system cost, which is an output of the NEMS model, represents the increment in the total cost of the system (including capital, operating and maintenance, fuel, transmission and distribution) that results from the PBF. But the NEMS output does not include the direct policy cost, so we add it to the system cost to approximate the full cost to society. We do not need to add the direct policy benefits because those are already reflected in incremental system cost that comes out of NEMS.

Key assumptions of the PBF analysis are that the PBF funds would generate the assumed level of private investment in energy efficiency through public education, R&D, demonstration projects, direct grants/buydowns/tax credits to subsidize advanced technologies, and low interest revolving loans.

Key Uncertainties: As with any assessment of the future, the PBF analysis has many uncertainties. Key uncertainties are, first, related directly to the key assumptions. If those assumptions are incorrect, then the results would change. Other key uncertainties are the ability of the NEMS model to give credible results for the SERC region and for the resulting changes in the SERC region to be fully attributable to policies implemented in North Carolina. Other uncertainties are the forecast of the price of fossil fuels, the cost, availability and operating characteristics of new power plants in the future, and the growth in the demand for electricity.

Description of Ancillary Benefits and Costs: The PBF 2 Mils policy analyzed here would result in reductions of criteria air pollutants as follows:

- SO₂: 732,000 tons (cumulative through 2025) or 38,500 tons (average per year)
- NO_x : 4,500 tons (cumulative through 2025) or 240 tons (average per year)
- Mercury: 3.1 tons (cumulative through 2025) or 361 pounds (average per year)

The PBF 5 Mils policy analyzed here would result in reductions of criteria air pollutants as follows:

- SO₂: 693,000 tons (cumulative through 2025) or 36,400 tons (average per year)
- NO_x : 2,200 tons (cumulative through 2025) or 115 tons (average per year)
- Mercury: 6.1 tons (cumulative through 2025) or 704 pounds (average per year)

Most reductions would occur later in the period, between 2015 and 2025.

The PBF 2 Mils policy results in a net 0.10% increase in overall electricity system costs (on a NPV basis) compared to the reference case. The PBF 5 Mils policy results in a 0.01% decrease. Unlike scenarios that involve mandatory builds of renewable capacity, neither level of PBF program shifts the system costs in a way that necessarily leads to economic development in North Carolina. Both scenarios result in lower capital investment (-\$0.21 for PBF 2 Mils and -0.16 for PBF 5 Mils) than in the reference case. Both scenarios have lower operating and maintenance expenses (-\$0.31 billion and -\$0.27 billion respectively). Fuel expenses go up relative to the reference case for both PBF scenarios (\$0.93 billion and \$0.20 billion). For the PBF 2 Mils scenario, transmission and distribution costs decrease by a total of \$0.07 billion, and in the PBF 5 Mils case, transmission and distribution costs decrease by \$0.32 billion. The direct cost of the PBF 2 Mils scenario amounts to \$0.15 billion, and the direct cost of the PBF 5 Mils scenario costs \$0.49 billion.

Description of Feasibility Issues: The implementation of a PBF program requires that an administrator be designated or created. The administrator is typically a new or existing state agency or a new or existing non-profit organization. As with any government or quasi-government agency, there will be costs associated with running the program. But many other states have such programs and have demonstrated that they are administratively feasible.

State Facilities Electricity Reduction Goal

Policy Description: North Carolina intends to reduce electricity consumption in State-owned buildings by 20% in 2008 and ramping up to 50% in 2016. These reductions, relative to the reference forecast of consumption in State-owned buildings, would result in a 560 GWh reduction in 2008 (0.43% reduction in total electricity demand in North Carolina) and a 1,760 GWh reduction in 2016 (1.18% total reduction). Specific measures that can be used to achieve this goal are 1) design new buildings to use as little electric lighting and space heating/cooling as possible through “green design” principles that take advantage of natural lighting, heating and cooling; 2) to meet or exceed EPA energy star specifications for all new equipment in buildings; 3) to retrofit old inefficient or ineffective components, such as windows, space heating/cooling equipment, and refrigerators; 4) and to replace boilers with or install new combined heat and power systems and distributed generation, included distributed renewables, wherever possible.

BAU Policies/Programs: TBD.

Types(s) of GHG Benefit(s): Reducing the demand for electricity and fuel in government buildings should lead to modest reductions in fossil fuel use and thus reduce GHG emissions.

Types of Ancillary Benefits and or Costs: Reductions in overall energy consumption and the shift from fossil fuel generation as a result of the state facilities reduction goal will lead to reductions in criteria air pollutants and, consequently, health costs associated with those pollutants. Much of the investment made as a result of the reduction goal will go into zero or low-cost (even negative cost) energy efficiency, which will more than pay for itself. Nevertheless, the impact on the larger electricity system of the state facilities target can lead to a small increase in overall electricity system cost for the SERC region.

Estimated GHG Savings and Cost per Ton CO2e:

	MMtCO2				
	2005	2010	2015	2020	2025
Reference	76	81	90	100	110
State Facilities Target	76	81	91	96	102
Reduction	0	-0.7	-0.9	3.9	8.0
Percent Reduction	0.0%	-0.9%	-1.0%	3.9%	7.2%

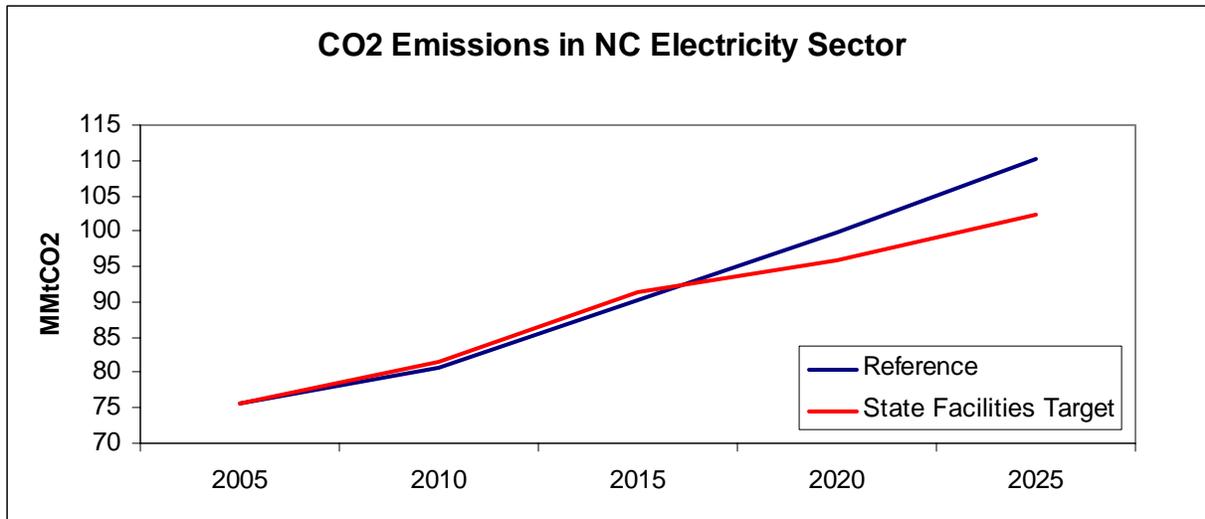
2005 = 2005, 2010 = average of 2006 - 2010, 2015 = average of 2011 - 2015 and so on

	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)
	Cumulative CO2 Reduction (MMtCO2) to 2025	Cumulative NC CO2 Emissions (MMtCO2) to 2025 with Policies	Percent Reduction	Direct Policy Cost (\$ NPV billions)	Direct Policy Benefits (\$ NPV billions)	Net Direct Policy Cost (\$ NPV billions)	\$/ton CO2 (Direct Cost)	SERC System Incremental Cost (\$ NPV billions)	System + Direct Cost (\$ NPV billions)	\$/ton CO2 (SERC System Cost)
State Facilities Target	50.8	1782	2.8%	\$0.14	\$0.33	(\$0.18)	(\$3.6)	\$0.64	\$0.78	\$15.4
NOTES:	CO2 reductions as a result of policy	Reference case emissions (1833 MMtCO2) - (a)	(a) / (b)	Direct incremental cost of policy out to 2025 ¹	Direct incremental benefits of policy out to 2025 ²	(d) - (e)	(f) * 1000 / (a)	Difference between policy and reference SERC region system cost out to 2025 ³	(d) + (h)	(i) * 1000 / (a)

¹ For example, renewable costs are total costs of renewables - total cost of equivalent amount of new fossil capacity. Direct Policy Costs are seen by the implementor of the policy

² For example, difference between the cost of efficiency and either the cost of generation (EPS) or the cost to the end user (Government Target). Direct Policy Benefits are seen by the implementor of the policy

³ Implicit in Incremental System Costs are Policy Benefits. Incremental System Costs represent the impact of the policy on the total cost of the electricity system within SERC, but do not reflect the Direct Policy Cost



2005 = 2005; 2010 = average of 2006 – 2010; 2015 = average of 2011

Data Sources, Methods and Assumptions: Most data for the electricity modeling done in this analysis comes from the US Energy Information Administration (EIA) and can be found within the National Energy Modeling System (NEMS). Data in NEMS includes representation of the existing generation, transmission and distribution system down to the unit level. NEMS also includes data that characterizes new plants that the model can choose to build to meet projected demand growth. EIA publishes *Assumptions to the Annual Energy Outlook* that details key assumptions in the current version of the model.³² EIA also publishes NEMS model documentation.³³

The specific levels of energy efficiency that are invested in as a result of the government policy were derived from state data on electricity consumption in state facilities³⁴ and the stated goal reduction goal in the State Energy Plan: 20% reductions from current baselines by 2008 and 4% per year for the next 5 years to include a 50% reduction by 2016 and maintenance of that level indefinitely. The cost of energy efficiency was based on costs for North Carolina in *Powering the South*.³⁵

The state facilities target was analyzed by lowering the demand for electricity in the commercial sector, which includes government, by an amount equal to the level of energy efficiency investment assumed by the state reduction goal. Total system costs, carbon dioxide emissions, and other outputs were compared with a reference case NEMS run. Because the NEMS model is a national model with multi-state regions (North Carolina is within the Southeastern Electric Reliability Council or SERC), the policy was implemented within the SERC region at a level for North Carolina. We make the assumption that the change in outputs in the entire region is attributed wholly to the policy in North Carolina. This assumption is reasonable given that the electricity market operates at a regional and even inter-regional level. Although we can collect

³² The document can be found here: [http://www.eia.doe.gov/oiaf/aeo/assumption/pdf/0554\(2005\).pdf](http://www.eia.doe.gov/oiaf/aeo/assumption/pdf/0554(2005).pdf)

³³ NEMS documentation can be found here: [http://www.eia.doe.gov/oiaf/aeo/overview/pdf/0581\(2003\).pdf](http://www.eia.doe.gov/oiaf/aeo/overview/pdf/0581(2003).pdf)

³⁴ Personal communication from Leonard Hoey of the North Carolina State Energy Office.

³⁵ Powering the South can be found here: <http://www.poweringthesouth.org/report/>

data within state bounds, any change in the electricity system within a given state will reverberate within the surrounding region and beyond.

For the direct policy costs and benefits, we analyzed the state facilities target from the perspective of the North Carolina government. These costs are the total costs incurred by the state in order to meet the reduction goal. The direct policy benefits are the cost savings to the state associated with avoiding the purchase of electricity resulting from energy efficiency investments.

The system cost, which is an output of the NEMS model, represents the increment in the total cost of the system (including capital, operating and maintenance, fuel, transmission and distribution) that results from the PBF. But the NEMS output does not include the direct policy cost, so we add it to the system cost to approximate the full cost to society. We do not need to add the direct policy benefits because those are already reflected in incremental system cost that comes out of NEMS.

Key assumptions of the state facilities target analysis are that the general efficiency investment assumed in the Powering the South study can be applied to state facilities. Most likely, the direct cost of reductions would be lower than the 2.6 cents per kWh assumed for this analysis.

Key Uncertainties: As with any assessment of the future, the state facilities target analysis has many uncertainties. Key uncertainties are, first, related directly to the key assumptions. If those assumptions are incorrect, then the results would change. Other key uncertainties are the ability of the NEMS model to give credible results for the SERC region and for the resulting changes in the SERC region to be fully attributable to policies implemented in North Carolina. Other uncertainties are the forecast of the price of fossil fuels, the cost, availability and operating characteristics of new power plants in the future, and the growth in the demand for electricity.

Description of Ancillary Benefits and Costs: The state facilities target analyzed here would result in reductions of criteria air pollutants as follows:

- SO₂: 757,000 tons (cumulative through 2025) or 39,800 tons (average per year)
- NO_x : 7,600 tons (cumulative through 2025) or 400 tons (average per year)
- Mercury: 2.3 tons (cumulative through 2025) or 270 pounds (average per year)

Most reductions would occur later in the period, between 2015 and 2025.

The state facilities target results in a net 0.16% increase in overall electricity system costs (on a NPV basis) compared to the reference case. Unlike scenarios that involve mandatory builds of renewable capacity, the state facilities target does not shift the system costs in a way that necessarily leads to economic development in North Carolina. This scenario results in lower capital investment (-\$0.17) than in the reference case. It has lower operating and maintenance expenses (-\$0.25). Fuel expenses go up relative to the reference case (\$1.07 billion). For this scenario, transmission costs increase by \$0.02 billion, and distribution costs decrease by \$0.03 billion. \$0.14 billion is invested in energy efficiency equipment.

Description of Feasibility Issues: The implementation of a state facilities reduction target is quite simple in that the state has only to decide to act. Plenty of opportunities for reduction can be found in state facilities at a low cost or even negative cost to the state.

Chapter 3 - Transportation and Land Use

State Vehicle Efficiency Improvements

Policy Description: This portfolio includes measures to procure efficient vehicles for the motor vehicle fleets owned by the State. The analysis examines three scenarios of increased efficiency of vehicles owned by the State: a 25 mile per gallon fuel economy of new vehicles purchased by the State, a 30 mile per gallon scenario, and a 35 mile per gallon scenario. These fuel economy values are applied to the fraction of new vehicles assumed to be state vehicle purchases starting with model year 2006 and continuing each model year through 2020. The values are applied to both passenger cars and light-duty trucks purchased by State agencies.

BAU Policies/Programs: TBD.

Types(s) of GHG Benefit(s): By spurring the use of energy efficient vehicles in the State, vehicle efficiency programs reduce the motor vehicle fuel consumptions, thereby leading to a reduction in CO2 emissions.

Types of Ancillary Benefits and or Costs: Reductions in fuel consumption as a result of the improved vehicle efficiency also leads to reductions in criteria air pollutants as well as reduced fuel costs to the consumer (in this case, the state government).

Estimated GHG Savings and Cost per Ton CO2e: The benefits of increased fuel economy in the State vehicle fleet, as well as the estimated annual fuel cost savings, are summarized in the table below:

Year	Scenario	Fuel Economy		Reduction in Gasoline Consumption		Reduction in CO2 Emissions	Annual Fuel Cost Savings (million \$)	
		Miles per Gallon	per Year	Billion Btu	Million Gallons	per MTCO2e	At \$2.00/gal	at \$2.50/gal
2010	1	25		157	1.255	11,020	2.51	3.14
	2	30		238	1.904	16,715	3.81	4.76
	3	35		296	2.367	20,782	4.73	5.92
2020	1	25		348	2.779	24,401	5.56	6.95
	2	30		533	4.260	37,411	8.52	10.65
	3	35		665	5.319	46,704	10.64	13.30

Incremental costs for obtaining vehicles with fuel economies of 25 mpg, 30 mpg, or 35 mpg above that of a baseline vehicle could not be quantified at this time.

Data Sources, Methods and Assumptions:

- **Data Sources:** Number of State fleet vehicles purchased in 2003 by make and model were provided by NC DAQ. Annual mileage accumulation rates by vehicle age for LDGVs and LDGTs were obtained from EPA's MOBILE6 emission factor model defaults.
- **Quantification Methods:** The number of miles driven annually by each of these higher efficiency vehicles was calculated first, based on adding an additional 658 higher efficiency LDGVs and 600 LDGTs each model year. The number of vehicles was multiplied by the assumed mileage accumulated by each vehicle, depending upon its age. The difference in fuel economy between a baseline LDGV (at 24 mpg) or LDGT (at 16 mpg) was then calculated and this fuel consumption was then converted to CO2 emissions.
- **Key assumptions:** This analysis assumes a constant number of State vehicles purchased each model year, starting in 2006, based on number purchased in 2003. After vehicles have reached their useful life for the State, these vehicles are sold and remain in use within North Carolina. The mileage accumulation rates for State vehicles was assumed to be the same as the national fleet average.

Key Uncertainties:

- **Benefits:** The number of vehicles purchased by the State may be underestimated. The number of vehicles included here may not include vehicles purchased by NCDOT.
- **Costs:** Gasoline costs are currently highly unstable. Depending upon future increases in the price of gasoline, the benefit of this policy may well outweigh the incremental purchase price of a more efficient vehicle.

Description of Ancillary Benefits and Costs:

Benefits: TBD.

Costs: TBD.

Description of Feasibility Issues: It should be noted that a majority of the NC 2003 light-duty vehicle purchases were flexible-fueled vehicles that can use either gasoline or up to a mixture of 85 percent ethanol and 15 percent gasoline. These purchases have been made in fulfillment of NC's EAct requirements. In general, these vehicles have lower fuel economy values than comparable gasoline-only vehicles. The feasibility of implementing an increased vehicle efficiency requirement on top of these EAct requirement needs to be further investigated.

VMT Reduction Portfolio

Policy Description: There are a variety of policies states can adopt that reduce vehicle miles traveled. Sometimes this portfolio is labeled "smart growth" or "anti-sprawl." This portfolio includes measures such as the following:

- Develop conservation and development plans with associated capital investment goals and strategies that meet regional needs and are consistent with the broad concepts of efficient land use planning and management.
- Redevelop brownfields, taking full advantage of federal monies available for these programs

- Promote transit-oriented development
- Identify methods and techniques that integrate local and regional land use planning and economic development strategies with multi-modal transportation planning and investment
- Protect open space and agricultural lands
- Improve existing transit services and new transit services
- Promote pedestrian scale streetscapes and give priority to pedestrian and bike access at all major developments
- Create more and expand existing pedestrian facilities linking neighborhoods with schools, employers, commercial areas, etc.
- Create longer and interconnected bike paths

The emission reductions from these policies are difficult to measure and accrue slowly.

A VMT reduction portfolio was analyzed using NC data and integrating experience in other states and localities. Reductions in growth in VMT of 1%-10% are possible.

BAU Policies/Programs: TBD.

Types(s) of GHG Benefit(s): Direct reduction in vehicle activity leading to significant reduction in GHG emissions.

Types of Ancillary Benefits and or Costs: Reductions in VMT growth will lead to direct corresponding reductions in emissions from criteria and hazardous air pollutants from light duty vehicles and trucks. The reductions in VMT will also lead to reductions in fuel consumption as a result of the reduced travel, which will reduce total fuel costs.

Estimated GHG Savings and Cost per Ton CO₂e: The table below summarizes the total reductions CO₂, CH₄, and N₂O resulting from the reduced VMT growth rates. The low VMT reduction scenario assumes that the rate of VMT growth from 2005 to 2010 is reduced by 5 percent and that the rate of VMT growth from 2005 to 2020 is reduced by 10 percent. The high VMT reduction scenario assumes that the rate of VMT growth from 2005 to 2010 is reduced by 10 percent and that the rate of VMT growth from 2005 to 2020 is reduced by 25 percent. These reductions are assumed to come from light-duty gas vehicles (LDGVs), light-duty gas trucks (LDGTs), light-duty diesel vehicles (LDDVs), light-duty diesel trucks (LDDTs), and motorcycles. This table also shows the total VMT reductions achieved in these scenarios. The costs associated with these scenarios have not been estimated at this time due to the large variability in costs associated with the wide variety of measures that could be used towards achieving these VMT reductions. However, a portion of the costs would be offset by the reduction in fuel consumption costs associated with the reduced VMT.

Scenario	Year	Total Reduction in VMT (million miles per year)	Total Reduction in GHG Emissions (MMTCO₂E per year)
Low VMT Reduction	2010	719	0.3467
	2020	6,933	3.4963
High VMT Reduction	2010	1,434	0.6917
	2020	16,801	8.4729

Data Sources, Methods and Assumptions:

- **Data Sources:** Information on projection year fuel economy values were obtained from MOBILE6 data.
- **Quantification Methods:** These estimates were calculated by first estimating the total rate of growth in VMT in the baseline projections from 2005 to 2010 and 2020 from LDGVs, LDGTs, LDDVs, LDDTs, and motorcycles. The annual baseline growth rate from 2005 to 2010 was 2.6 percent per year and the annual baseline growth rate from 2005 to 2020 was 3.1 percent per year. Total VMT from these vehicle categories was then recalculated after reducing the VMT growth rate by the amount specified for each scenario. The resulting total VMT was then distributed by vehicle category using the same mix as in the baseline 2010 and 2020 VMT estimates. Emission reductions of CH₄ and N₂O were calculated by multiplying the baseline projected emissions by each of the five light-duty vehicle categories by the ratio of the VMT reduced for that vehicle category to the baseline VMT for that vehicle category in the specified year. To calculate CO₂ emission reductions, the VMT reductions were converted to fuel consumption reduction estimates. The CO₂ emission reductions were then calculated using the same equations as the baseline CO₂ emission projections, but based on the fuel consumption reduced rather than total fuel consumption.
- **Key assumptions:** The VMT growth rate reduction percentages were selected to be representative of what could possibly be achieved using some combination of the VMT reduction strategies listed above. To convert the VMT reductions to fuel consumption reductions, the following fuel economy values were assumed: 24 mpg for LDGVs; 16 mpg for LDGTs; 32 mpg for LDDVs; 20 mpg for LDDTs; and 50 mpg for motorcycles.

Key Uncertainties:

Benefits: The actual VMT reductions that can be achieved with each of the measures listed above are difficult to quantify. However, it is expected that some combination of these measures could achieve the modeled VMT growth rate reductions.

Costs: Since specific VMT reduction measures were not modeled, the cost associated with achieving these VMT growth rate reductions has a wide range of uncertainty.

Description of Ancillary Benefits and Costs:

- **Benefits:** Exhaust emissions from criteria and hazardous air pollutants would also be reduced in direct proportion to the VMT reductions from the light-duty vehicles and trucks. The low VMT reduction scenario leads to a 0.6 percent VMT reduction from LDVs and LDTs in 2010 and a 4 percent reduction in 2020. Under the high VMT reduction scenario, LDV and LDT VMT is reduced by 1 percent in 2010 and 11 percent in 2020. Exhaust LDV and LDT emissions from criteria and hazardous air pollutants would be reduced by roughly these same percentages.
- **Costs:** The costs for achieving these ancillary emission reductions would be the same as the costs or savings that would be incurred to obtain the GHG emission benefits. No additional

costs would need to be incurred to obtain the criteria and hazardous air pollutant emission reductions.

Description of Feasibility Issues: TBD.