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# Agriculture, Forestry, and Waste Management Technical Work Group

## Summary List of Recommended Priority Policy Options for Analysis

| Option No. | Policy Option | | | GHG Reductions ($MMtCO_2e$) | | | Net Present Value 2008–2020 (Million $) | Cost-Effective-ness ($/tCO_2e$) | Level of Support |
|---|---|---|---|---|---|---|---|---|---|
| | | | | 2012 | 2020 | Total 2008–2020 | | | |
| AFW-1 | On-Farm Energy Efficiency | | | | | | | | Pending |
| AFW-2 | On-Farm Waste Energy Recovery | | | | | | | | Pending |
| AFW-3 | Expanded Use of Local Agricultural Products | | | | | | | | Pending |
| AFW-4 | In-State Liquid Biofuels Production | Biodiesel -based on in-state feedstock supply | | 0.15 | 0.16 | 1.79 | 40.8 | 22.8 | Pending |
| | | Ethanol -lower limit production goal | | 0.28 | 0.90 | 5.76 | 74.9 | 13.0 | |
| AFW-5 | Expanded Production of In-State Biomass for Electricity, Heat, or Steam Production | | | | | | | | Pending |
| AFW-6 | Terrestrial Carbon Sequestration | (a) Agriculture | | | | | | | Pending |
| | | (b) Forestry | Forest Management | 0.86 | 2.22 | 15.2 | 139 | 9.16 | |
| | | | Afforestation / Reforestatoin | 0.81 | 2.44 | 15.8 | 158 | 9.99 | |
| | | | Urban Forestry | | | | | | |
| AFW-7 | Conservation and Restoration of Forest and Agriculture Lands for Enhanced Carbon Sequestration | | | | | | | | Pending |
| AFW-8 | Advanced Recycling and Composting | | | 1.18 | 3.01 | 20.1 | TBD | TBD | Pending |
| AFW-9 | Organics Management for Energy Recovery | | | | | | | | Pending |
| AFW-10 | Water and Wastewater Energy Efficiency Improvements | | | | | | | | Pending |
| | **Sector Total After Adjusting for Overlaps** | | | | | | | | |
| | **Reductions From Recent Actions** | | | | | | | | |
| | **Sector Total Plus Recent Actions** | | | | | | | | |

# AFW-1. On-Farm Energy Efficiency

## Policy Description

Renewable energy may be produced and used on-site at individual agricultural operations or regionally through farm cooperatives to achieve better economy of scale. For example, on-farm production and use of solar heating and biofuels will reduce carbon dioxide emissions by displacing the use of fossil based fuels.

Energy conservation for agricultural operations will result in increased efficiency. For example, improved irrigation systems save both water and energy, and expanded use of precision agriculture systems will also result in reduced fossil fuel usage.

GHG benefits can also be achieved indirectly through better use of organic fertilizers (manure) to offset commercial fertilizers, which require intensive energy inputs for production, transportation and application. These indirect (lifecycle) benefits are covered within option AFW-6a (soil carbon management).

## Policy Design

**Goals:**

Fossil fuel reduction goal: 20% reduction in petro-diesel use by 2020, over 2007 baseline.

Electricity reduction goal: 30% reduction, including both electricity efficiency and on-site generation using renewable energy, over 2007 baseline.

**Timing:**

Fossil fuel reduction goal: Achieve 5% reduction by 2012. Achieve the full policy goal by 2020.

Electricity reduction goal: Achieve 10% reduction by 2012. Achieve the full policy goal by 2020.

**Parties Involved:** SC Department of Agriculture; SC DNR – Conservation Districts; SCDHEC; SC Energy Office; Clemson University – Cooperative Extension Service; USDA – Natural Resources Conservation Service; USDA – Rural Development; SC Farm Bureau; Businesses providing energy efficiency and renewable energy equipment and services.

**Other:** As needed, identify incentives that encourage the energy reductions through audits, maintenance, equipment modification, and developing feedstocks and availability of renewable energy.

## Implementation Mechanisms

TBD – [CCS drafts based on TWG inputs; this can be developed as they go along, and can start early or late as they prefer; the level of detail can vary on TWG approval]

## Related Policies/Programs in Place

TBD – No recent policies or programs have been identified as of yet. The TWG and DHEC can work with CCS to identify existing or planned programs that address issues raised in this option.

## Type(s) of GHG Reductions

Displacement of coal, natural gas, and other fossil fuels reduces emissions of fossil carbon. Increased energy efficiency decreases the amount of carbon emitted per unit of economic productivity. On-farm capture or production of renewable energy reduces the need for consumption of fossil energy, and displaces the associated fossil carbon emissions.

## Estimated GHG Reductions and Net Costs or Cost Savings

TBD – [CCS should provide a worksheet and other reference material as needed for transparency]

**Data Sources:** Consumption of distillate fuel by the agriculture sector in South Carolina is projected from historical data provided by the Energy Information Administration (EIA).[1] The petro-diesel emissions factor used is consistent with the South Carolina I&F (10.07 $MtCO_2e$/1,000 gal). The agricultural sector electricity consumption was derived from the National Agriculture Statistics Service (NASS)[2] and historical electricity prices from the EIA.[3] The cost-effectiveness estimates are based on various sources throughout the literature. Data and case studies specific to South Carolina were used whenever possible.

**Quantification Methods:**

*GHG Benefit*

The quantification of the GHG benefits of this option will follow the following process:

- Establish the baseline on-farm petro-diesel and electricity usage. Data for diesel consumption are directly available from the EIA. Electricity usage is estimated based on expenditure and price data.
- Use lifecycle emission factors consistent with those used with the SC I&F for diesel and electricity to estimate the GHG reduction achieved through the goals set forth by this option.

*Cost Effectiveness*

The quantification of the cost effectiveness of this option will follow the following process:

[1] Energy Information Administration. "South Carolina Total Distillate Sales/Deliveries to Farm Consumers." 1984–2005. Accessed on January 18, 2007, at http://tonto.eia.doe.gov/dnav/pet/hist/kd0vfmssc1a.htm.

[2] National Agricultural Statistics Service. "Colorado Agriculture: A Profile." 2005 data. Accessed on August 20, 2007. Not yet retrieved.

[3] Energy Information Administration. "Current and Historical Monthly Retail Sales, Revenues, and Average Retail Price by State and by Sector (Form EIA-826)." Not yet retrieved.

- Calculate cost savings realized from reduction in consumption of diesel fuel and electricity.

- Add cost of incentive and/or education program needed to implement goals (need TWG input).

- Add cost of agriculture energy audit (need TWG input).

- Add additional annual cost of new equipment and/or upgrades of current equipment. This will require a breakdown of how much energy is used on specific farm practices in SC (need TWG input).

**Key Assumptions: [**TBD, as needed on TWG approval]

## Key Uncertainties

TBD – [as needed and approved by the TWGs]

## Additional Benefits and Costs

TBD – [as needed and approved by the TWGs]

## Feasibility Issues

TBD – [as needed and approved by the TWGs]

## Status of Group Approval

Pending – [until CECAC moves to final agreement at meeting #5 or #6]

## Level of Group Support

TBD – [blank until CECAC meeting #5]

## Barriers to Consensus

TBD – [blank until final vote by the CECAC]

# AFW-2. On-Farm Waste Energy Recovery

## Policy Description

Reduce the amount of methane emissions from livestock manure by installing manure digesters on livestock operation. Reduce the amount of excess nitrogen applied to crops from poultry litter by promoting gasification, pyrolysis and other thermochemical conversion methods for energy recovery. Energy from manure digesters is used to create heat or power, which offsets fossil fuel-based energy production and the associated GHG emissions. Thermochemical conversion and other methods of waste-to-energy may be more advantageous than anaerobic digestion. Energy from these processes will also reduce the GHG emissions and may be used to produce synthesis gas and hydrocarbon fuels. As with AFW-1, these energy recovery projects can be implemented at individual livestock operations or collectively at groups of operations in order to achieve better economies of scale.

## Policy Design

**Goals:** Capture 15% of available energy from animal feeding operations (AFOs) through methane capture (anaerobic digestion), thermochemical conversion, or other renewable energy means.

**Timing:** By 2012, implement projects to capture 5% of available methane energy at hog farms and dairies, and 5% of surplus litter at poultry and turkey farms. By 2020, implement projects to capture 15% of methane energy and 15% of litter.

**Parties involved:** SC Department of Agriculture; SC DNR – Conservation Districts; SCDHEC; SC Energy Office; Clemson University – Cooperative Extension Service; USDA – Natural Resources Conservation Service; USDA – Rural Development; USDA – Agricultural Research Service; SC Farm Bureau; hog, dairy, and poultry farmers; Businesses providing energy efficiency and renewable energy equipment.

**Other:** As needed, identify incentives that encourage the renewable energy production on all AFOs in SC. Determine the optimal technologies and management methods from perspective of on-farm economics and GHG mitigation/reduction. Digester economics may improve with additional feedstocks beyond manure, including spoiled or culled produce and other agricultural residues. Note the potential linkage to AFW-9, which addresses energy recovery from municipal solid waste.

## Implementation Mechanisms

TBD – [CCS drafts based on TWG inputs; this can be developed as they go along, and can start early or late as they prefer; the level of detail can vary on TWG approval]

## Related Policies/Programs in Place

The USDA-Agricultural Research Service is conducting research on thermochemical waste-to-energy from animal manures for AFO waste streams. The State Energy Office has conducted analyses quantifying animal waste in South Carolina.

## Type(s) of GHG Reductions

**$CH_4$:** methane is captured and typically combusted in an energy recovery system or flared. Small amounts of $N_2O$ and $CH_4$ are emitted from the combustion process.

**$CO_2$:** carbon dioxide is reduced when the methane is converted to energy and that energy is used to offset fossil-based energy (e.g., coal-fired electricity, natural gas, etc.). Small amounts of $N_2O$ and $CH_4$ are also reduced from the fossil-based energy that is offset.

**$N_2O$:** By avoiding land-application of surplus litter, nitrous oxide emissions are reduced by poultry-litter-to-energy installations. (Under wet conditions, excess nitrogen in soils increases the microbial reactions that release $N_2O$.)

Also, displacement of coal, natural gas, and other fossil fuels reduces emissions of fossil carbon. Increased energy efficiency decreases the amount of carbon emitted per unit of economic productivity. On-farm capture or production of renewable energy reduces the need for consumption of fossil energy, and displaces the associated fossil carbon emissions.

## Estimated GHG Reductions and Net Costs or Cost Savings

TBD – [CCS should provide a worksheet and other reference material as needed for transparency]

**Data Sources: [**TBD by CCS on TWG approval]

**NOTE: Do we have resource data for manure digesters?**

Final Report on Availability of Poultry Litter as Biomass Energy, http://www.scbiomass.org/Publications/Poultry%20Litter%20Final%20Report.pdf (416 k PDF) “It is estimated that between 400,000 and 700,000 tons of poultry and turkey litter are produced per year.”

**Quantification Methods:**

*GHG Benefits from Manure*
Methane emissions (in MMt CO2-e) data from the South Carolina Agriculture Inventory and Forecast was used as the starting point to estimate the GHG benefits of capturing and controlling the volumes of methane targeted by the policy and to add in the additional benefit of electricity generation using this captured methane (through offsetting fossil-based generation). The first portion of GHG benefit is obtained through reduced methane emissions through the capture of

emissions from manure. An assumed collection efficiency of 75%[4] was applied to methane emissions from animal manure which was then multiplied by the assumed policy target ramping up to achieve 15% collection by 2020.

The second portion of the GHG benefit is through the offsetting of fossil-based electricity generation. This was estimated by converting the captured methane in each year to its heat content (in BTUs) and then multiplying by an energy recovery factor of 17,100 BTU/kW-hr to estimate the electricity produced (assumes a 25% efficiency for conversion to electricity in an engine and generator set). The $CO_2e$ associated with this amount of electricity in each year was estimated by converting the kW-hrs to MW-hrs and then multiplying this value by the South Carolina-specific emission factor for electricity production from eGRID (0.415 Mt/MWh).

The total GHG benefit was estimated as the sum of both portions of the benefit described above and indicated in Table X.

**Table X: GHG Benefits from Dairy and Swine**

| Year | Methane Emissions From Dairy, and Swine (MMt CO2-e) | Policy Utilization objective | Methane Captured and Utilized under policy (MMt CO2-e) | Million Metric Tons of Methane | Methane (million BTUs) | CO2e Offset as Electricity (Metric Tons) | Total Emission Reductions (MMt CO2-e) |
|---|---|---|---|---|---|---|---|
| 2008 | 0.152 | 1% | 0.001 | 0.000 | 2,854 | 69 | 0.001 |
| 2009 | 0.154 | 2% | 0.002 | 0.000 | 5,790 | 141 | 0.002 |
| 2010 | 0.156 | 3% | 0.004 | 0.000 | 8,808 | 214 | 0.004 |
| 2011 | 0.157 | 4% | 0.005 | 0.000 | 11,792 | 286 | 0.005 |
| 2012 | 0.157 | 5% | 0.006 | 0.000 | 14,800 | 359 | 0.006 |
| 2013 | 0.158 | 6% | 0.007 | 0.000 | 18,575 | 451 | 0.008 |
| 2014 | 0.159 | 8% | 0.009 | 0.000 | 22,379 | 543 | 0.009 |
| 2015 | 0.159 | 9% | 0.010 | 0.000 | 26,213 | 636 | 0.011 |
| 2016 | 0.160 | 10% | 0.012 | 0.001 | 30,118 | 731 | 0.013 |
| 2017 | 0.161 | 11% | 0.014 | 0.001 | 34,064 | 827 | 0.014 |
| 2018 | 0.162 | 13% | 0.015 | 0.001 | 38,049 | 923 | 0.016 |
| 2019 | 0.163 | 14% | 0.017 | 0.001 | 42,075 | 1,021 | 0.018 |
| 2020 | 0.163 | 15% | 0.018 | 0.001 | 46,141 | 1,120 | 0.020 |

4 The collection efficiency is an assumed value based on engineering judgment. No applicable studies were identified that provided information on methane collection efficiencies achieved using manure digesters (as it relates to collection of entire farm-level emissions).

*Costs for Manure*

The costs for this component are to be estimated using average annualized capital costs for digester to energy projects likely sourced from the EPA methane to markets report or more appropriate SC-specific data, if available.

**Key Assumptions: [**TBD, as needed on TWG approval]

## Key Uncertainties

TBD – [as needed and approved by the TWGs]

## Additional Benefits and Costs

TBD – [as needed and approved by the TWGs]

## Feasibility Issues

TBD – [as needed and approved by the TWGs]

## Status of Group Approval

Pending – [until CECAC moves to final agreement at meeting #5 or #6]

## Level of Group Support

TBD – [blank until CECAC meeting #5]

## Barriers to Consensus

TBD – [blank until final vote by the CECAC]

# AFW-3. Expanded Use of Local Agricultural Products

## Policy Description

Promote the production and consumption of locally produced agricultural commodities, which displace the consumption of commodities transported from other states or countries. Greenhouse gas (GHG) reductions occur from reduced transportation-related emissions and from local farms that institute GHG reduction practices that may not be instituted in other states or countries.

## Policy Design

**Goals:** To increase the production, storage, and processing of locally grown animal products, grains, vegetables, and fruits and their consumption in South Carolina such that at least 25% of these products purchased in South Carolina are produced by South Carolina farmers and ranchers. Begin tracking this information so it is readily available for planning purposes.

**Timing:** To increase sales and consumption of local farm products by 50% and increase storage and processing capacity of locally grown farm products by 100% above current levels by 2012. Increase purchasing of South Carolina-produced agriculture products to 25% of total purchased agriculture products in SC by 2020.

**Parties Involved:** SC Department of Agriculture (SCDA); SC Farm Bureau (SCFB); Palmetto Agri-Business Council; Clemson University – Cooperative Extension Service; US Department of Agriculture (USDA); Carolina Farm Stewardship Association; SC Food Policy Council.

**Other:** State current baseline information here.

## Implementation Mechanisms

Continue funding for the South Carolina Department of Agriculture's marketing and branding program for South Carolina grown commodities. Furthermore, identify incentives that encourage retail chains in SC to sell locally grown products. The SCDA also needs to increase or facilitate development of, and support for, more local farmers markets which both increase the financial return for small producers and encourage more small producers. **NOTE TO TWG: Text moved from "Other" to Implementation Mechanisms by B. Strode on 1/18/08.**

## Related Policies/Programs in Place

Seeds of Hope, a local farmers' market program in Columbia, has weekly markets at 12+ sites during the growing season. The USDA lists 63 farmers markets in the state.

The SC Agribusiness Development Program is responsible for the development of new products (both traditional and non-traditional) that add value to the state's agricultural products. Since 1994, the "South Carolina Quality" marketing program has worked with supermarket chains to purchase and sell fresh produce grown in South Carolina, specifically encouraging customers to buy local produce in supermarkets. DOA also has the "Certified SC Grown" program to promote SC agricultural products.

## Type(s) of GHG Reductions

**$CO_2$:** Reduction in $CO_2$ emissions due to a reduction in ton-miles required to bring out-of-state agriculture products to markets in South Carolina. Although not quantified in this analysis, it is possible that processing of products in-state may yield additional GHG benefits not related to the averted long-range transport of produce and other agricultural products.

## Estimated GHG Reductions and Net Costs or Cost Savings

TBD – [CCS should provide a worksheet and other reference material as needed for transparency]

**Data Sources:** U.S. per capita food consumption was taken from the USDA Economic Research Service (ERS) Food Availability (Per Capita) Data System.[5] South Carolina production and export data is available by product-type through the USDA National Agriculture Statistics Service (NASS).[6] The average travel distances of imported foods are taken from an Iowa study of food miles.[7]

**Quantification Methods:**

*GHG Benefits*

The quantification of the GHG benefits of this option will follow the following process:

- Use US per-capita food consumption to estimate SC food consumption by product type.

**Table 3-1. Per capita consumption of food types, by category**

| Food Category | US per capita consumption (lbs) |
|---|---|
| Red meat | 116 |
| Chicken | 86 |
| Turkey | 17 |
| Fish | 12 |
| Eggs | 33 |
| All dairy | 601 |
| Fats and oils | 87 |
| Peanuts | 7 |
| Tree nuts | 3 |
| Coconut | 1 |
| Fresh fruit | 122 |
| Canned fruit | 15 |
| Dried fruit | 2 |

[5] http://www.ers.usda.gov/Data/FoodConsumption/FoodAvailSpreadsheets.htm

[6] Yet to be retrieved.

[7] Food, Fuel, and Freeways: An Iowa perspective on how far food travels, fuel usage, and greenhouse gas emissions. Leopold Center for Sustainable Agriculture. 209 Curtis Hall Iowa State University Ames, Iowa 50011-1050 Website: http://www.leopold.iastate.edu/

| Food Category | US per capita consumption (lbs) |
|---|---|
| Frozen fruit | 5 |
| Fruit juice | 72 |
| Fresh vegetables | 184 |
| Canned vegetables | 108 |
| Frozen vegetables | 75 |
| Legumes | 6 |
| Dehydrated vegetables | 14 |
| Potatoes for chips, shoestrings | 16 |
| Grains | 192 |
| Coffee, tea, cocoa | 20 |
| Spices | 3 |
| Beverages | 116 |
| **Total** | **1,911** |

- For agricultural products produced in SC, subtract the quantity produced from the quantity exported to determine the baseline in-state consumption of SC agricultural products.
- Use Iowa farm study to estimate the food miles of imported and locally grown food. Apply fuel consumption assumptions to estimate $CO_2$ emissions reduction for incremental increase in consumption of locally-grown food.

*Cost Effectiveness*

The quantification of the cost effectiveness of this option will follow the following process:

- Make contact with industry expert to establish the cost of increased in-state storage and processing.
- Add the net change in cost of food paid by consumers for locally grown food (source TBD).
- Add the net change in price received by farmers for in-state markets (source TBD).
- Subtract the cost savings yielded by reduced fuel consumption derived from the reduced number of food miles.

**Key Assumptions: [**TBD, as needed on TWG approval]

## Key Uncertainties

TBD – [as needed and approved by the TWGs]

## Additional Benefits and Costs

TBD – [as needed and approved by the TWGs]

## Feasibility Issues

TBD – [as needed and approved by the TWGs]

## Status of Group Approval

Pending – [until CECAC moves to final agreement at meeting #5 or #6]

## Level of Group Support

TBD – [blank until CECAC meeting #5]

## Barriers to Consensus

TBD – [blank until final vote by the CECAC]

# AFW-4. In-State Liquid Biofuels Production

## Policy Description

The ultimate goal of South Carolina is to take full advantage of resources available in the state through agriculture, forestry, or other biomass feedstocks to displace the use of fossil fuels. South Carolina is in an excellent position to develop an in-state alternative fuels industry that will provide economic opportunities for rural communities looking for alternatives to a fading tobacco and cotton industry. Policies must be developed in South Carolina that will attract investors, retailers, and purchasers to produce and use the fuels in the state (Note the linkage of this option covering in-state production of biofuels with the TLU option covering consumption of biofuels through a low carbon fuel standard). The focus of this policy should be in-state biofuels production based on in-state feedstocks.

In 2006 and 2007, South Carolina passed attractive incentives that have been able to promote and expand this industry. To date, the incentives have been effective and a great deal of interest within the alternative fuels industry has been generated. Other potential incentives for alternative fuel producers include expanding existing tax credits for biodiesel and ethanol to include other low-GHG future fuels such as butanol and hydrogen.

*NEED TO CHECK WITH TLU  Note: This option is linked with TLU-12 on a Low GHG Fuel Standard and TLU-6 on Alternative Fuel Infrastructurs. This AFW option seeks to achieve incremental GHG benefits beyond the TLU option by promoting in-state production of biofuels using feedstocks with greater GHG benefits than the likely BAU national production methods.*

## Policy Design

**Goals:**

South Carolina's numerical targets for biodiesel and ethanol production by 2020 include:

*Lower Limit Targets*

* based on estimated growth of 25% every five years for biodiesel and an expansion of 50 MGY for ethanol facilities every five years.

| Phase | Year | Gallons of biodiesel produced in South Carolina | Represents percentage of total diesel used in state (based on projected use)[8] | Gallons of ethanol produced in South Carolina | Represents percentage of total gasoline used in state (based on projected use)[9] |
|---|---|---|---|---|---|
| 1 | 2010 | 81,000,000 | 10.4 % | 100,000,000 | 3.7% |
| 2 | 2015 | 100,000,000 | 11.4% | 150,000,000 | 5% |

[8] Based on data collected by the SC Energy Office and Global Insights in *SC Energy Outlook*, January 2008.

[9] Based on data collected by the SC Energy Office and Global Insights in *SC Energy Outlook*, January 2008.

| | | | | | |
|---|---|---|---|---|---|
| 3 | 2020 | 125,000,000 | 12.5% | 200,000,000 | 6.5% |

*Upper Limit Targets* (contingent on current or increased price of crude oil, availability of technology advancements and development of cheaper feedstocks, and maintenance of federal government incentives):
* based on estimated growth of 50% every five years for biodiesel and an expansion of 200 million gallons of ethanol every five years.

| Phase | Year | Gallons of biodiesel produced in South Carolina | Represents percentage of total diesel used in state (in FY 2007) | Gallons of ethanol produced in South Carolina | Represents percentage of total gasoline used in state (in 2006) |
|---|---|---|---|---|---|
| 1 | 2010 | 100,000,000 | 12.9 % | 100,000,000 | 4% |
| 2 | 2015 | 150,000,000 | 17% | 300,000,000 | 10.2% |
| 3 | 2020 | 225,000,000 | 22.5% | 500,000,000 | 16.3% |

**Timing:** See table above.

**Parties Involved:** State of South Carolina, farmers, biofuels producers, distributors, fuel retailers, fuel wholesalers, business owners, and relevant agriculture and trade associations.

**Other:** Note to TWG: CECAC requests that the costs and benefits be assessed at two different levels of implementation – one based on the goals in the table above; and the other at the level that the TWG feels is the upper bound of potential feedstock availability.

Currently there are no commercial cellulosic ethanol plants in the United States. One large plant is under construction in Georgia, one has just broken ground in Montana and a few others are being planned across the country. There are no ethanol plants in South Carolina. There are two biodiesel plants in production and three more planned.

## Implementation Mechanisms

The state could provide additional economic benefits such as:

- No state property tax for alternative fuel production facilities and a tax exemption on the purchase of equipment.
- A special exception for alternative fuel producers related to the Jobs Creation Tax Credit
- Higher state-owned pump alternative fuel requirements from B5 to B20 and provide greater state facility access to E85.
- Continue state funding for alternative fuel marketing and education programs.

- Maintain and enhance the current state tax rebates and state income tax credits for low-GHG emission alternative fuel production. Among the improvements needed in state legislation are presented in Act No. 83, 2007 include:

  1. SC Code 12-6-3600 – Remove the six month requirement prior to claiming tax credit.
  2. SC Code 12-6-3631 – Tax credit for R&D on alternative fuel feedstocks - remove the $100,000/year cap. Additionally, remove the limitation that each company can only claim $100,000 over all years.
  3. SC Code 12-6-3600 – Tax credit for ethanol and biodiesel production – remove $800,000/year cap.
  4. SC Code 12-6-3610 – Tax credit for ethanol and biodiesel dispensing equipment and amendment to include production equipment for intermediate steps of alternative fuel production (ex: crushing facilities) - remove $150,000/year cap.
  5. SC Code 46-3-260 - Secure funding for the SC Renewable Energy Grants and Loans program in subsequent years.

## Related Policies/Programs in Place

South Carolina currently provides Biodiesel Production Tax Credits in the amount of $0.20 per gallon of biodiesel or ethanol produced from soybean oil or corn feedstocks and $0.30 per gallon of biodiesel or ethanol from feedstocks other than soybean oil and corn. There is also a 25% tax credit for the purchase and installation of equipment directly related to the production of ethanol and biodiesel.

Several on-going alternative fuel production facilities include:

- Carolina Biofuels - a new division of the Taylors, South Carolina-based company Carolina Polymers, rolled out their first load of biodiesel fuel on March 14, 2006. Carolina Biofuels manufacturing facilities are currently in full operation, and though starting at 10 million gallons of biodiesel fuel expect to grow to over 30 million gallons annually. A large percentage of the fuel produced at Carolina Biofuels is sold to World Energy Alternatives, LLC which is leading global supplier of biodiesel located out of Massachusetts. Carolina Biofuels supports South Carolina industry by using locally-grown soybeans to make their fuel, and as production ramps up, they will create between 20 and 30 jobs in the Taylors area.
- Southeast Biodiesel - In May 2007 the facility begin commercially selling biodiesel made from poultry fat in North Charleston. The company's grand opening was October 27, 2006. Southeast Biodiesel expects to begin by producing six million gallons and eventually increase production once there is more demand in the Charleston area. The company is currently selling biodiesel fuel to local shrimpers.
- Ecogy Biofuels, LLC – the company will build a biodiesel plant across the street from an existing soy oil crusher, Carolina Soya. Construction of the Ecogy Biofuels, LLC plant is expected to be completed and producing biodiesel at the close of 2007. The plant is being

constructed to produce 30 million gallons of fuel annually. Ecogy Biofuels has begun research and development of alternative oils, including oils derived from algae.

- Aiken Biofuels – formerly known as Farmers and Truckers Biodiesel, this facility has converted a Warrenville clay warehouse in Aiken County to a 5 million gallon/year facility at a cost of approximately $1.4 million. The facility has the potential to expand to 20 million gallons/year and will use feedstocks such as soy oil, cotton seed oil, and animal fats to produce the biodiesel.
- Greenlight Biofuels - The Virginia based company plans to expand operations into South Carolina in 2008 with a 10 million gallon per year plant in Laurens. The $8.5 million facility will generate 15 jobs. Greenlight Biofuels will use vegetable oils, animals fats, and recycled restaurant grease to make the biodiesel which will be sold to local retail stations and also used for home heating oil and off-road motors.

Clemson University, the University of South Carolina, and other research institutions are working vigorously to develop a viable cellulosic ethanol industry. South Carolina has also formed an algae-to-biodiesel collaborative among state businesses to develop indigenous oil feedstocks. In-state retailers have also embraced alternative fuels and to-date South Carolina has 49 publicly-accessible E85 and 49 publicly-accessible biodiesel pumps. Additionally, beginning July 1, 2008 there will be in-state incentives for consumers to purchase vehicles that operate on E85. Despite the good intent of some of the in-state incentives there is an immediate need to clarify and correct legislation for alternative fuel producers in Act No. 83, 2007.

Additional recent programs and/or policies related to alternative fuel production in South Carolina are available through Act No. 83, 2007, Act. No.116, 2007, and the FY08 Budget Appropriations. These programs include:

- Tax credits for R&D into cellulosic ethanol and algae-derived biodiesel.
- Tax credit for equipment to produce renewable fuel.
- Low-interest loans for the production of transportation fuels from biomass (SC Renewable Energy Revolving Loan Program).
- One-time funding for the Dept. of Ag. Biofuels Marketing Program.
- One-time funding to purchase biodiesel and ethanol testing equipment to offer free ASTM testing for in-state producers as well as recurring funding for additional staff.

## Type(s) of GHG Reductions

**$CO_2$:** Lifecycle emissions are reduced to the extent that biodiesel and ethanol is produced with lower embedded fossil-based carbon than conventional (fossil) fuel. Feedstocks used for producing biodiesel and ethanol can be made from crops or other biomass, which contain carbon sequestered during photosynthesis (e.g., biogenic or short-term carbon).

The primary feedstocks for biodiesel are vegetable oils (soy, canola, sunflower, algal, etc.) and alcohols (either methanol or ethanol). From a recent report (Hill et al., 2006),[10] biodiesel from soybeans contains 93% more useable energy than its petroleum equivalent and reduces lifecycle GHG emissions by as much as 41%. Higher oil production potential of different feedstocks (e.g., other oil crops, algae) will likely adjust the lifecycle GHG emissions further downward as they are developed as biodiesel sources. Local production of biodiesel also decreases the embedded $CO_2e$ of biodiesel compared to importation of out of state vegetable oil supplies.

There are two different methods for producing ethanol based on two different feedstocks. Starch-based ethanol is derived from corn or other starch/sugar crops. Cellulosic ethanol is made from the cellulose contained in a wide variety of biomass feedstocks, including agricultural residue (e.g., corn stover), forestry waste, purpose grown crops (e.g., switchgrass), and municipal solid waste. Local production of ethanol also decreases the embedded $CO_2e$ of ethanol compared to importation from the current U.S. primary ethanol producing regions. Current research indicates cellulose-based ethanol production provides up to 72%–85% reduction in GHGs compared to gasoline, whereas an 18%–29% reduction is measured from starch-based ethanol production compared to gasoline.

## Estimated GHG Reductions and Net Costs or Cost Savings

**Biodiesel**

*Scenario A – Based on lower limit TWG production goals*

- GHG reduction potential in 2012, 2020 ($MMtCO_2e$) **based on TWG goals**: 0.19, 0.32
- Net Cost per $MtCO_2e$: $16.06

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*Scenario B – Based on upper bound limits of in-state feedstock supply*

- GHG reduction potential in 2012, 2020 ($MMtCO_2e$) **based on upper bound of potential feedstock availability**: 0.15, 0.16
- Net Cost per $MtCO_2e$: $22.80

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*Scenario C – Based on lower limit TWG production goals with new technologies meeting in-state feedstock supply shortfalls*

- GHG reduction potential in 2012, 2020 ($MMtCO_2e$) **based on TWG goals and new technology**: 0.36, 0.70
- Net Cost per $MtCO_2e$: $7.97

[10] Hill et al., 2006, "Environmental, economic, and energetic costs and benefits of biodiesel and ethanol biofuels," *Proceedings of the National Academy of Sciences*, 103:11206–11210, July 25, 2006.

**Ethanol**

*Scenario A – Based on TWG lower limit production goals*

- GHG reduction potential in 2012, 2020 (MMt$CO_2$e): 0.28, 0.90
- Net Cost per Mt$CO_2$e: $13.00

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*Scenario B – Based on TWG upper limit production goals*

- GHG reduction potential in 2012, 2020 (MMt$CO_2$e) 0.28, 3.22
- Net Cost per Mt$CO_2$e: $7.29

**Data Sources:** Data from the SC Draft Inventory & Forecast were the starting point for quantifying the benefits of offsetting fossil diesel and gasoline consumption with biodiesel and ethanol produced within the state (these do not incorporate future reductions in consumption due to TLU options). Gasoline consumption estimates are (under business as usual):

| Year | Gasoline consumption (Mmgal/year) |
|---|---|
| **2012** | 2,013 |
| **2020** | 2,145 |

The lower limit policy design calls for 100 MMgal/year production, 150 MMgal/y, and 200 MMgal/y by 2010, 2015, and 2020, respectively. The upper limit policy design calls for 100 MMgal/year production, 300 MMgal/y, and 500 MMgal/y by 2010, 2015, and 2020, respectively Ethanol has approximately 67% the heat content of gasoline.[11] Emission factors from gasoline, starch-based ethanol and cellulosic ethanol are based on the ANL Greet Model.[12] The lifecycle $CO_2$e emission factor used for gasoline used is 11.74 Mt/1,000 gallons, for starch-based ethanol is 9.60 Mt/1,000 gallons, and for cellulosic ethanol is 3.28 Mt/1,000 gallons.[13] The production cost differential for cellulosic versus starch-based ethanol was obtained from the National Renewable Energy Laboratory (NREL).[14]

Fossil diesel consumption estimates are (under business as usual):

**BAU Diesel Consumption**

[11] DOE/EIA, http://www.eia.doe.gov/oiaf/analysispaper/biomass.html, accessed January 9, 2008

[12] Ibid.

[13] ANLGreet model emission factor in g/mi x GREET model average fuel economy (100 mi/4.7 gal).

[14] http://www.nrel.gov/technologytransfer/entrepreneurs/pdfs/19_forum/braemar_cellulosic.pdf, slide 21, accessed December 2007

| Year | Diesel consumption (Mmgal/year) |
|---|---|
| **2012** | 929 |
| **2020** | 1,148 |

The lower limit policy design calls for production of 81 MMgal/year, 100 MMgal/year, and 125 MMgal/year biodiesel by 2010, 2015, and 2020, respectively, with a focus on in-state production based on in-state feedstock. The upper limit policy design calls for production of 100 MMgal/year, 150 MMgal/year, and 225 MMgal/year biodiesel by 2010, 2015, and 2020, respectively

The BAU biodiesel production is based upon the current and planned biodiesel capacity of SC. A capacity factor of 50% is assumed. See the table below for the existing and planned facilities in SC:

**Current and planned biodiesel production facilities in South Carolina**

| Facility Name | Status | Capacity (1000 gal) | Feedstock | Misc. |
|---|---|---|---|---|
| Carolina Biofuels | In-production | 10,000 | Soy (In-state) | Potential to expand to 30,000 |
| Southeast Biodiesel | In-production | 6,000 | Poultry fat | |
| Ecogy Biofuels, LLC | Planned 2008 | 30,000 | Soy | |
| Aiken Biofuels | Planned 2008 | 5,000 | Soy, Cottonseed, Animal Fat | Potential to expand to 20,000 |
| Greenlight Biofuels | Planned 2009 | 10,000 | Veg Oil, Animal Fat, Yellow Grease | |

The $CO_2e$ emission factor for fossil diesel used in the inventory and forecast is 10.07 Mt/1,000 gallons. The lifecycle fossil diesel emission factor is 12.3 Mt/1,000 gallons.[15]

**Quantification Methods:**

*GHG Reductions*

The benefits for this option are dependent on developing in-state production capacity that achieves benefits above the levels of using ethanol from starch-based production, which may already be accounted for under the Transportation and Land Use low GHG Fuel Standard policy recommendations.

Based on the emission factors listed above, the incremental benefit of the production targeted by this policy over conventional starch-based ethanol is 6.32 Mt/1,000 gallons, or a 66%. This value

[15] From: Hill, J., et. al., Proceedings of the National Academy of Sciences, vol. 103, no. 30, 11206-11210. U.S. soybean-based biodiesel.

was used along with the production in each year to estimate GHG reductions.[16] This analysis does not take into account the benefits from transitioning from gasoline to corn-based ethanol.

For biodiesel production a new study on lifecycle GHG benefits for biodiesel production and use was used to estimate the $CO_2$e reductions for this option.[17] This study covered biodiesel production from soybean production, which is currently the predominant feedstock source for biodiesel production in the US and is assumed to remain that way for the purposes of this analysis (it is also the predominant feedstock of biodiesel production in SC). Lifecycle $CO_2$e reductions (via displacement of fossil diesel with soybean-derived biodiesel) were estimated by Hill et al. to be 41%. This value is being used by the TLU TWG to estimate the benefit of the biodiesel component of the TLU biofuels option. Hence, this analysis focuses on incremental benefits of in-state feedstocks.

For this option, the incremental benefit of in-state production is derived from the carbon avoided from having to transport the feedstocks from their likely source region. For this assessment, the likely source region for soybean is the U.S. mid-west. Using the Iowa/Illinois border as a potential source region, rail transport would require shipments to central South Carolina of about 950 miles.[18] Rail fuel consumption is about 423 ton-miles/gallon.[19] From these inputs, a GHG emission rate of 507 $MtCO_2$/MMgal biodiesel produced was calculated.

In addition to soybean oil, other oil feedstocks included in this analysis include animal oils (yellow grease, poultry fat, lard, and tallow), cottonseed, peanut oil, sunflower oil, and algal oils. It is assumed that technology advances will occur during the policy period that will allow for commercial scale production of algal oil to make up approximately 5% of biodiesel production by 2020. With sufficient technology advancement, another option could be Fischer-Tropsch biodiesel from cellulose.

For oil sources other than soybean oil, the benefit for substituting in-state biodiesel for fossil diesel is estimated starting with the lifecycle soybean emission factor (7,261 $MtCO_2$e/MMgal from the Hill et al. study). As mentioned previously, the benefits of the biodiesel component of the TLU biofuels option is based on displacement with soybean-based biodiesel. Hence, this analysis was designed to only account for the incremental benefit of in-state feedstock (oil) production using GHG preferential feedstocks. These include vegetable oils that produce greater volumes of oil per unit of energy input, animal fats, yellow grease, and, in the future, algal oils.

Canola produces 127 gallons of oil per acre compared to soybeans at 48 gallons/acre. Assuming canola production energy inputs are not significantly greater than soy, the lifecycle emission rate for canola would be 7,261 x 48/127 or 2,744 $MtCO_2$e/MMgal. So the incremental benefit of canola over soy is 7,261–2,744 = 4,517 $MtCO_2$e/MMgal. However, South Carolina produces essentially no canola (rapeseed) so current canola feedstock is assumed to be imported from the U.S. northern plains. Using North Dakota as a potential source region, rail transport would

[16] ANLGreet model emission factor in g/mi x GREET model average fuel economy (100 mi/4.7 gal).

[17] Ibid.

[18] Google Maps directions, Davenport, Iowa to South Carolina; www.maps.google.com.

[19] Association of American Railroads, http://www.aar.org/getFile.asp?File_id=466.

require shipments to central South Carolina of about 1700 miles, reducing the incremental benefit of canola over soy by 907 MtCO2e/MMgal biodiesel to 3607 MtCO2e/MMgal.[20]

Cottonseed produces less oil than soy - 35 gallons/acre compared to soybeans at 48 gallons/acre.[21] Assuming cottonseed production energy inputs are not significantly greater than soy, the lifecycle emission rate would be 7,261 x 48/35 or 9,957.3 MtCO2e/MMgal. So the incremental "benefit" of cottonseed over soy is 7,261 - 9,957.3 or a net loss of (2696.8) MtCO2e/MMgal biodiesel.

Sunflower seed produce102 gallons/acre compared to soybeans at 48 gallons/acre.[22] Assuming cottonseed production energy inputs are not significantly greater than soy, the lifecycle emission rate would be 7261 x 48/102 = 3416.9 MtCO2e/MMgal. The incremental benefit of sunflower over soy is 7261 - 3416.9 = 3844.1 MtCO2e/MMgal biodiesel.

Peanuts yield 113 gallons/acre compared to soybeans at 48 gallons/acre.[23] Assuming peanut production energy inputs are not significantly greater than soy, the lifecycle emission rate would be 7261 x 48/113 = 3048.3 MtCO2e/MMgal. The incremental benefit of peanut over soy is 7261 - 3048.3 = 4176.7 MtCO2e/MMgal biodiesel.

For animal fats, algal oils, and yellow grease CCS assumes that these have negligible embedded energy. So the incremental benefit over soy equals the soybean based EF (7,261 Mt$CO_2$e/MMgal) minus transportation costs, which are assumed to average 100 miles[24], yielding a benefit of 7,207 MtCO2e/MMgal biodiesel over soy-based.

## Ethanol

*Scenario A*

In Scenario A the GHG emissions benefits and cost were calculated for the lower limit TWG goals. Ethanol production needed was assumed to ramp up from replacing 0% of BAU gasoline consumption in 2007 to 5% in 2010. GHG reductions were estimated by multiplying the cellulosic ethanol production requirement by the incremental benefit of using cellulose over corn.

In-state cellulose supply was estimated from non-harvested cropland and residual biomass residues. The South Carolina non-harvested cropland from 2002 was estimated by subtracting harvested cropland from total cropland. [25] The conversion factors below were used to estimate dry mass from cropland and ethanol from cellulose based on DOE and NREL data.[26]

[20] Google Maps directions, North Dakota to South Carolina; www.maps.google.com.

[21] http://journeytoforever.org/biodiesel_yield.html, accessed January 8, 2008.

[22] http://journeytoforever.org/biodiesel_yield.html, accessed January 8, 2008.

[23] http://journeytoforever.org/biodiesel_yield.html, accessed January 8, 2008.

[24] Average max dimension of SC is 200 miles, 100 miles is average distance from center of the state to border.

[25] 2002 production, http://www.nass.usda.gov/census/census02/volume1/sc/st45_1_001_001.pdf, Table 1

[26] http://genomicsgtl.energy.gov/biofuels/2005workshop/2005low_intro.pdf, accessed December 28, 2008; J. Ashworth, NREL, personal communication, 4/06/07.

**Cellulose feedstock conversion factors**

| Year | Cellulose yield per acre (tons) | Ethanol yield from cellulose (gal/ton biomass) |
|---|---|---|
| 2008 | 5 | 70 |
| 2012 | 7.5 | 90 |
| 2020 | 10 | 100 |

Additional estimates of biomass from crop residues, switchgrass on Conservation Reserve Program (CRP) land, forest residues, primary and secondary mill residues, and urban wood were obtained from an NREL study.[27] The following table shows calculated cellulosic ethanol annual production maxima based on the upper bound of feedstock supplies.

**Cellulosic ethanol annual production based on upper bound of feedstock supplies**

| Year | Cellulosic ethanol (1,000 gal) |
|---|---|
| 2008 | 1,200 |
| 2009 | 314,985 |
| 2010 | 314,985 |
| 2011 | 314,985 |
| 2012 | 404,981 |
| 2013 | 566,973 |
| 2014 | 566,972 |
| 2015 | 566,972 |
| 2016 | 566,972 |
| 2017 | 809,961 |
| 2018 | 809,961 |
| 2019 | 809,961 |
| 2020 | 899,957 |

Sweet potato and sweet sorghum feedstock potential were also calculated based on USDA crop data[28] with yields of 2000 and 500 gallons ethanol per acre, respectively.[29] However, as these crops contribute a much smaller fraction of potential feedstock supply than cellulose, it was assumed that they would not be needed for production and all calculations were based on using cellulose to meet TWG goals.

[27] A Geographic Perspective on the Current Biomass Resource Availability in the United States,

A. Milbrandt, NREL, December 2005

[28] http://www.nass.usda.gov/Publications/Ag_Statistics/2007/index.asp

[29] E. Hartwig, SC Energy Office, personal communication, Jan 2008; http://www.ars.usda.gov/research/publications/publications.htm?seq_no_115=195472, accessed January 14, 2008.

| Crop | Cellulosic ethanol potential (1,000 gal) |
|---|---|
| Sweet Potato | 1,533 |
| Sweet Sorghum | 4,666 |

*Scenario B*

In Scenario B the GHG emissions benefits and cost were calculated for the upper limit TWG goals.

*Costs*

For ethanol, costs for the incentives needed by this policy option are based on the difference in estimated production costs between conventional starch-based ethanol and cellulosic ethanol. Estimates taken from an NREL-sponsored industry forum estimate a production cost of $1.31 per gallon for corn-based ethanol and $1.97 per gallon for cellulose-based, resulting in a differential of $0.66 per gallon.[30] These estimates include capitals costs so additional incentives for capital and R&D are not included in this analysis. These incentives are considered necessary in the near term to help commercialize technologies that produce ethanol from cellulose. The incentives should also help to establish the infrastructure to deliver biomass to biorefineries, since producers will seek the local feedstocks or renewable fuels for their operations, although this may also be covered in the TLU Alternative Fuel Infrastructure policy option.

By 2015, it is assumed that advances in cellulosic ethanol production (e.g., enzyme costs, production processes) will make cellulosic ethanol production cost competitive with starch-based production. Hence, the incentives are discontinued beginning in 2015. Note that federal legislation has been proposed to offer cellulose an incentive of $0.765/gallon compared to the $0.51/gallon currently offered for ethanol production.[31] If enacted, this $0.255/gallon premium could cover the additional incentives that are assumed to be needed by the State of South Carolina. Obviously, the federal incentives do not assure that production facilities would locate in SC, hence these federal incentives have not been factored into the cost estimates for this option.

**Biodiesel**

*Scenario A*

[30] http://www.nrel.gov/technologytransfer/entrepreneurs/pdfs/19_forum/braemar_cellulosic.pdf, slide 21, accessed December 2007

[31] D. Morris, *Making Cellulosic Ethanol Happen: Good and Not So Good Public Policy*, Institute for Local Self-Reliance, January 2007, at www.newrules.org/agri/cellulosicethanol.pdf, accessed January 2007.

To meet the in-state production goals the table below provides the mix of oil feedstocks assumed in this analysis based on transitioning from the current and planned production mix of feedstocks used to all-in-state feedstocks.

**Assumed mix of oil feedstocks**

| Year | Oil Feedstock | Fraction of New Production | MMgal/yr Needed |
|---|---|---|---|
| 2012 | Soy (out-of-state) | 0.19 | 17 |
| 2012 | Soy | 0.50 | 45 |
| 2012 | Other Veg oil | 0.10 | 9 |
| 2012 | Animal fats | 0.17 | 15 |
| 2012 | Algal | 0.00 | 0 |
| 2012 | Yellow grease | 0.03 | 3 |
| **2012 Total** | | | 89 |
| 2020 | Soy (out-of-state) | 0.00 | 0 |
| 2020 | Soy | 0.64 | 81 |
| 2020 | Other Veg oil | 0.10 | 13 |
| 2020 | Animal fats | 0.17 | 21 |
| 2020 | Algal | 0.05 | 6 |
| 2020 | Yellow grease | 0.03 | 4 |
| **2020 Total** | | | 125 |

Excludes planned production capacity of 48 Mmgal/year.

GHG reductions were estimated by multiplying the new production above BAU for each oil feedstock by the applicable incremental benefit (e.g., by oil type). Total reductions in each year were estimated by summing the incremental benefit for each oil type.

*Scenario B*

In-state oilseed feedstock supplies were estimated by measuring the average 2004-2006 South Carolina production yields of soybean, cottonseed, peanut, and sunflower and assuming that 100% of production would go towards biodiesel. Animal fats available were estimated based on the ratio of South Carolina livestock/poultry slaughter/production to that of Minnesota, given that detailed amounts of grease, lard, poultry fat, and tallow available in Minnesota are known from their Bio-Power Evaluation Tool (BioPET) that identifies locations, types, and volumes of biomass fuels.[32] Yellow grease was projected based on industry estimates of 14 pounds restaurant grease per capita and 7.6 pounds of grease per gallon using US Census projections for

[32] http://www.mncee.org/pdf/biomassreport.pdf, accessed January 8, 2008.

South Carolina.[33] It was assumed that by 2020 algal biodiesel technology will have progressed enough to be available to provide 5% of biodiesel needs.

**Available biodiesel feedstock potential**

| Feedstock | Biodiesel equivalent (1000 gal) |
|---|---|
| Soybean oil | 15,278 |
| Cottonseed oil | 33 |
| Peanut oil | 6,579 |
| Sunflower oil | 295 |
| Animal fats | 7,347 |
| yellow grease 2012 | 8,586 |
| yellow grease 2020 | 9,151 |
| Algal 2020 - estimated at 5% of feedstock | 1,590 |
| **total 2012** | **38,117** |
| **total 2020** | **40,272** |

The mix of feedstocks assumed was based on respective proportion of each feedstock of the upper-bound of in-state supply.

**Assumed mix for in-state feedstocks alone**

| Year | Oil Feedstock | Fraction of New Production | MMgal/yr Needed |
|---|---|---|---|
| 2012 | Soy (out-of-state) | 0.00 | 0 |
| 2012 | Soy | 0.49 | 15 |
| 2012 | Other Veg oil | 0.00 | 0 |
| 2012 | Animal fats | 0.24 | 7 |
| 2012 | Algal | 0.00 | 0 |
| 2012 | Yellow grease | 0.27 | 9 |
| **2012 Total** | | | 31 |
| 2020 | Soy (out-of-state) | 0 | 0 |
| 2020 | Soy | 0.38 | 15 |
| 2020 | Other Veg oil | 0.17 | 7 |
| 2020 | Animal fats | 0.18 | 7 |

[33] http://media.cleantech.com/node/376, accessed January 8, 2008; http://www.cgfa.org/news.html, under Evaluate The Cost And Usage Of Various Fuels, accessed January 8, 2008; http://www.census.gov/population/www/projections/projectionsagesex.html, table 6, accessed December 28, 2007.

| | | | |
|---|---|---|---|
| 2020 | Algal | 0.04 | 2 |
| 2020 | Yellow grease | 0.23 | 9 |
| **2020 Total** | | | 40 |

The BAU current and planned production outpaces the upper bound of in-state potential feedstock by 2008. GHG estimates for this scenario were calculated by multiplying total production of each oil feedstock by the applicable incremental benefit without subtracting BAU production. After 2008, production is assumed to be capped based on the upper bound of potential feedstock supply. Total reductions in each year were estimated by summing the incremental benefit for each oil type.

*Scenario C*

To meet the lower limit in-state production goals the table below provides the mix of oil feedstocks assumed in this analysis based on transitioning from the current and planned production mix of feedstocks used to all-in-state feedstocks. New algal technology was assumed to make up the shortfall between the upper bound of potential in-state feedstock supply and the TWG in-state production goals.

**Assumed mix of feedstocks with new technology meeting goal shortfall**

| Year | Oil Feedstock | Fraction of New Production | MMgal/yr Needed |
|---|---|---|---|
| 2012 | Soy (out-of-state) | 0.00 | 0 |
| 2012 | Soy | 0.38 | 34 |
| 2012 | Other Veg oil | 0.17 | 15 |
| 2012 | Animal fats | 0.18 | 16 |
| 2012 | Algal | 0.06 | 5 |
| 2012 | Yellow grease | 0.21 | 19 |
| **2012 Total** | | | 89 |
| 2020 | Soy (out-of-state) | 0.00 | 0 |
| 2020 | Soy | 0.20 | 25 |
| 2020 | Other Veg oil | 0.10 | 13 |
| 2020 | Animal fats | 0.12 | 15 |
| 2020 | Algal | 0.50 | 63 |
| 2020 | Yellow grease | 0.12 | 15 |
| **2020 Total** | | | 130 |

Excludes planned production capacity of 48 Mmgal/year.

GHG reductions were estimated by multiplying the new production above BAU for each oil feedstock by the applicable incremental benefit. Total reductions in each year were estimated by summing the incremental benefit for each oil type.

GHG emissions were not calculated for upper limit TWG goals because they far exceeded feedstock supply.

*Costs*

Costs were estimated using information from an analysis of biodiesel production costs from the US DOE.[34] The value of incentives needed is assumed to be $0.30/gallon - the value of incentives offered in a State of Missouri incentives program.[35] In Oct 2004 when the $0.30 Missouri biodiesel incentive passed, there was only 1 biodiesel plant under construction in Missouri; by the end of 2007, Biodiesel magazine lists 8 plants in operation or under construction in the state.[36] This program offers production incentives to producers up to 15 million gallons of production/yr. The incentive grants last for five years. Hence, CCS only applied the incentives costs to the first five years of the policy period.

CCS assumed a similar incentive structure and that these would cover the costs of all grants or tax incentives associated with this policy (all other implementation mechanisms are assumed to be achieved within existing programs). The cost estimates are based on multiplying the amount of biodiesel produced in each year above BAU by the production incentive. This assumes that all production occurs at production facilities of less than 15 million gallons/yr. The production incentive runs out after five years of production.

**Key Assumptions:** Upper bound feedstock potential is based on the assumption that 100% of feedstocks identified go towards fuel and not other uses. New technologies such as algal biodiesel and rigorous cellulosic production that can use a variety of feedstock types are assumed to progress quickly enough to be implemented within the policy period.

## Key Uncertainties

Cost competitiveness of biofuels will depend on cost of oil.

The Energy Information Administration (EIA) has stated "Capital costs for a first-of-a-kind cellulosic ethanol plant with a capacity of 50 million gallon per year are estimated by one leading producer to be $375 million (2005 dollars), as compared with $67 million for a corn-based plant of similar size, and investment risk is high for a large-scale cellulosic ethanol production facility. Other studies have provided lower cost estimates. A detailed study by the National Renewable Energy Laboratory in 2002 estimated total capital costs for a cellulosic ethanol plant with a capacity of 69.3 million gallons per year at $200 million."[37]

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[34] See www.eia.doe.gov/oiaf/analysispaper/biodiesel/index.html; accessed January 2007.

[35] Information on the Missouri Program from www.newrules.org/agri/mobiofuels.html#biodiesel,accessed January 2007.

[36] http://www.renewableenergyaccess.com/rea/news/story?id=21253, accessed January 9, 2008; http://www.biodieselmagazine.com/plant-list.jsp?view=production&sort=state&sortdir=asc&country=USA, accessed January 9, 2008.

[37] http://www.eia.doe.gov/oiaf/analysispaper/biomass.html, accessed December 2007

In June 2006, a U.S. Senate hearing was told that the current cost of producing cellulosic ethanol is US $2.25 per US gallon (US $0.59/litre). This is primarily due to the current poor conversion efficiency. At that price it would cost about $120 to substitute a barrel of oil (42 gallons), taking into account the lower energy content of ethanol. However, the Department of Energy is optimistic and has requested a doubling of research funding. The same Senate hearing was told that the research target was to reduce the cost of production to US $1.07 per US gallon (US $0.28/litre) by 2012.

Transitioning to large amounts of energy crop cultivation for biofuels has the potential for a negative impact on biodiversity.

Transitioning to large amounts of energy crop cultivation for biofuels has the potential for a negatively impact on biodiversity.

A key uncertainty with this option is in estimating the incremental benefit above what is achieved with the low carbon fuel standard. To estimate benefits for in-state production of ethanol using GHG-superior technologies and feedstocks, one must make critical assumptions about what types of fuels will supply the low carbon fuel standard within the policy period. For the purposes of this analysis, CCS has assumed that the primary low carbon fuel that will be used to lower the carbon content of gasoline-powered vehicles will be starch-based ethanol and Midwest-grown soy. The incremental benefit is based on the higher GHG benefits associated with producing ethanol in-state using cellulosic ethanol technology and feedstocks and biodiesel from in-state feedstocks. To the extent that this technology is widely employed within the policy period and acts as a significant supplier of fuel to meet the low carbon standard, the incremental benefits estimated here could be overstated.

## Additional Benefits and Costs

Potential for competition with the production of food; less impact by cellulosic ethanol than corn ethanol on water quality and could actually reduce nutrient loads in some circumstances; permanent new sources of income for farmers and foresters; using current waste streams to replace US fuel consumption; environmental benefits or costs; recycling money in local economies; stimulation of potential markets for other biomass feedstocks (forest treatment biomass, municipal solid waste fiber); increased transportation energy security with shorter transport distances and on-farm use of fuel produced; reduced reliance on imported petroleum.

## Feasibility Issues

Implementation of this option requires additional research and development in cellulosic ethanol production methods, development of feedstock collection and delivery infrastructure, successful negotiations with cellulosic technology leaders to establish pilot and commercial-scale plants in the state. Sourcing of feedstocks and the size and location of facilities (both crushing and biodiesel production) must be addressed for optimization and planning. Trade-offs between food and fuel crops will be an important issue. Full implementation of biodiesel goals requires quick research advancement in algal oil harvesting.

There may be an overlap among agricultural options that seek to increase/maintain crop acreage in no-till production or in conservation management programs. This could be in conflict with the higher levels of crop production proposed in this option.

## Status of Group Approval

Pending **–** [until CECAC moves to final agreement at meeting #5 or #6]

## Level of Group Support

TBD **–** [blank until CECAC meeting #5]

## Barriers to Consensus

TBD **–** [blank until final vote by the CECAC]

# AFW-5. Expanded Production of In-State Biomass for Electricity, Heat, or Steam Production

## Policy Description

Offset fossil fuel use with production of electricity, steam, and heat from biomass resources. Provide incentives for the development of new biomass production and collection infrastructure, as well as incentives for energy end users that are equitable throughout the economy. Local electricity, heat, or steam production yields greatest net energy payoff. According to a recent study by La Capra and the SC Electric Cooperatives, South Carolina currently has 360 MW of installed capacity for woody biomass. Based on available wood and agriculture residue inventories as well as energy crop production potential, South Carolina has the ability to more than double the current level of production.[38]

**Table XX: Current and Potential Electricity Generation Capacity from Biomass Feestocks**

| | Current Installed Capacity (MW) | Technical Potential (MW) | Practical Potential (MW)[39] | Practical Generation (GWh) |
|---|---|---|---|---|
| **Wood Biomass** | 360 | 1,599 | 423 | 3,148 |
| **Agricultural By-Products** | 0 | 362 | 68 | 504 |
| ***Total*** | ***360*** | ***1,961*** | ***491*** | ***3,652*** |

The focus of this policy is on programs needed to increase the availability of biomass feedstocks for use in-state. Policies to encourage use of this resource are addressed within the ES and RCI sectors.

## Policy Design

**Goals:** Increase production of electricity, steam, and heat generation to utilize 25% of the available wood and agriculture residue biomass by 2020, equivalent to 122MW over the 2007 baseline of 360MW of installed biopower capacity. By 2030, expand electricity, steam, and heat generation from biomass resources to utilize 50% of the available biomass (246 MW over the 2007 baseline).

**Timing:** Increase biomass electricity, steam, and heat generation to utilize an additional 10% of available resource by 2010, equivalent to 49 MW of increased capacity. By 2012, increased capacity should reach 68 MW, utilizing 14% of practical and available resource. By 2020,

[38] La Capra Associates and GDS Associates. 2007. "Analysis of Renewable Energy Potential in South Carolina." Prepared for: Central Electric Power Cooperative Inc. September 12, 2007. Accessed on January 8, 2008 from: http://www.ecsc.org/newsroom/RenewablesStudy.ppt.

[39] The La Capra study defines "Practical Potential" as "the maximum potential that might reasonably be expected to be implemented."

increased capacity should reach 122 MW, utilizing 25% of practical and available resource. By 2030, increased capacity should reach 246 MW, utilizing 50% of practical and available resource.

**Coverage of Parties:**

SC Department of Agriculture, South Carolina Forestry Commission, University of South Carolina, Clemson University and Extension agencies, SC State University, SC Energy Office, South Carolina Department of Health and Environmental Control – Air Quality Division, SC Biomass Council, SC Forestry Association and SC Forestry Commission, Palmetto Institute, SC Institute for Energy Studies, SC Public Service Commission, Office of Regulatory Staff, SC Department of Revenue, Electric Utilities and Rural Electric Cooperatives, Livestock & Poultry Producers, Crop Producers, and Timberland Owners.

**Other:** Explore biomass production for utilization in electricity, steam, and heat generation using 100% biomass and/or co-firing with other feedstocks. [NOTE: This policy has parallel policy options in ES and RCI covering utilization of biomass; the focus here is on production]. Note to TWG, the CECAC would also like the TWG to include utilization of woody energy crops along with residues.

## Implementation Mechanisms

A broad range of policy mechanisms and programs should be used to foster development of the industry and associated economic markets, including voluntary, incentive-based programs and regulatory requirements. These could include:

- Establish a state-level renewable electric portfolio standard (REPS), requiring a specific percentage of in-state generation to be fueled by biomass.
- Establish an interconnection standard that allows utility-scale combined heat and power production, and distributed generation fueled by biomass.
- Establish net metering rates by utilities, electric cooperatives, and municipalities that allow biomass energy to be price competitive (i.e., rates should be greater than avoided cost).
- Establish output-based emissions regulations (OBR) that encourage energy efficiency and biomass energy as air pollution control measures.
- Increase state-level incentives, especially those for construction of new utility-scale generating capacity using biomass resources.
- Establish competitive cost-share grant funding for feasibility studies for new utility-scale generating capacity using biomass resources.
- Stream-lining the permitting process for biomass-to-energy projects and technical assistance for new producers.
- Incentives in the form of grants or tax breaks (sales and/or income) for incurred capital costs for feedstock producers.
- Expanded consumer and end-user education to drive demand.
- Expanded producer education to develop skilled workforce.

- Active state involvement in new projects.
- State rebates for equipment purchase (ex: a rebate for each kW or kW-equivalent of energy installed).
- Removing state tax on the purchase of renewable energy equipment.

## Related Policies/Programs in Place

**Legal Definition:**

In South Carolina state law, biomass is defined as wood, wood waste, agricultural waste, animal waste, sewage, landfill gas, and other organic materials.

**Incentives:**

*Incentive Payment:*
Beginning July 1, 2008, a business is allowed an incentive payment for production of electricity or methane gas fuel in a facility not using biomass resources before June 30, 2008, or in a facility which produces at least twenty-five percent more electricity or methane from biomass resources than the greatest three-year average before June 30, 2008. This includes:

- 1 cent per kilowatt-hour (kWh) for electricity.
- 9 cents per therm for methane gas fuel.

*Equipment Tax Credit:*
Beginning July 1, 2007 there is a credit against the income tax for twenty-five percent of the costs incurred by a taxpayer for the purchase and installation of equipment used to create heat, power, steam, electricity, or another form of energy for commercial use from a fuel consisting of no less than ninety percent biomass resource. Costs incurred by a taxpayer and qualifying for the credit allowed by this section must be certified by the State Energy Office, in consultation with the Department of Agriculture and the South Carolina Institute for Energy Studies. A taxpayer's credit utilization in any one year, for all expenditures allowed pursuant to this section, must not exceed six hundred fifty thousand dollars. Unused credits may be carried forward for fifteen years.

**Conducive Policies:**

In December 2006, the SC Public Service Commission (PSC) adopted a simplified interconnection standard for small distributed generation (DG). The standard addresses renewable-energy systems and other forms of DG up to 20 kilowatts (kW) in capacity for residential systems, and up to 100 kW in capacity for non-residential systems. The standard does not include provisions for three-phase generators, and limits the range of commercially viable interconnections.

## Type(s) of GHG Reductions

Displacement of coal, natural gas, and other fossil fuels reduces emissions of GHGs. Increased energy efficiency of smaller-scale generating technologies decreases the amount of carbon emitted per unit of energy generated.

## Estimated GHG Reductions and Net Costs or Cost Savings

TBD – [CCS should provide a worksheet and other reference material as needed for transparency]

**Data Sources:**

The South Carolina Energy Office has quantified the following potential for taking advantage of biomass that is currently not being used for fueling a sustainable bioenergy industry:

- 14 million tons of green wood from forest thinnings.
- 621,000 tons of urban waste wood that currently goes into landfills.
- 1.2 million tons of agricultural residues from fields planted in corn, soybeans, and cotton.

There is a case study about cofiring biomass with coal at the DOE Savannah River Cofiring Project in South Carolina in 2004 on page 22 of a DOE Federal Energy Management Program document titled "Biomass Cofiring in Coal-Fired Boilers."

The South Carolina Electric Cooperative Association commissioned an informative study of biopower resource potential. Here is a link to the report, written by consultants GDS Associates and LaCapra Associates. http://www.energy.sc.gov/news.aspx?id=52 This study found 9.8 m dry tons per year of woody biomass potential, determined to have a cost of less than $65 per dry ton or about $4.00 per MMBtu.

The South Carolina Forestry Commission performs annual inventories of wood residues: http://www.state.sc.us/forest/prod.htm

**Quantification Methods:**

This analysis focuses on the incremental GHG benefits associated with the utilization of additional biomass to offset the consumption of fossil fuels. The analysis assumes that biomass will replace 100% coal. This is based on the assumption that the majority of biomass will be used to replace coal through co-firing opportunities in the RCI and electricity sector (where coal represents a significant proportion of electricity generated[40]). The amount of biomass available is taken from La Capra Associates and GDS Associates. 2007. "Analysis of Renewable Energy Potential in South Carolina." Prepared for: Central Electric Power Cooperative Inc. September 12, 2007. Accessed on January 17, 2008 from: **http://www.ecsc.org/newsroom/RenewablesStudy.ppt**.

**Table X: Estimated Available Agriculture Biomass**

[40] Based on eGRID data for SC: Nuclear 52%, Coal 40%, Natural Gas 3.9%, Biomass 1.7%, Hydro 1.3%, Oil 0.9%.

| Agricultural Resources | Approximate Dry Tons per year required[41] | Maximum Fuel (MMbtu) | Assumed Capacity Factor | Technical Potential (MW) [42] |
|---|---|---|---|---|
| Corn | 906,928 | 7,480,346 | 85% | 72 |
| Wheat | 408,683 | 3,370,815 | 85% | 32 |
| Soybean | 404,696 | 3,337,936 | 85% | 32 |
| Cotton | 502,617 | 4,145,582 | 85% | 40 |
| **Total crop Residue** | 2,222,924 | 18,334,679 | 85% | 176 |
| Switchgrass | 2,035,756 | 16,790,918 | 85% | 161 |
| **Crop Residue and Switchgrass** | 4,258,681 | 35,125,597 | 85% | 337 |

**Table X: Estimated Available Wood Biomass**

| Wood Biomass Options | Dry Tons per Year | Annual Heat Value3 (MMBtu) | Technical Potential (MW)[43] |
|---|---|---|---|
| Logging Residue | 2,205,750 | 37,497,750 | 360 |
| Pre-commercial Thinnings | 4,277,898 | 72,724,266 | 698 |
| Commercial Thinnings | 2,668,000 | 45,356,000 | 435 |
| Southern Scrub Oak1 | 24,396 | 414,732 | 4 |
| Net Available Mill Residue | 6,043 | 102,731 | 1 |
| Urban Wood Waste | 621,000 | 10,557,000 | 101 |
| **Total Wood Biomass** | **9,803,087** | **166,652,479** | **1599** |

Biomass produces are assumed to reduce emissions by 0.0940 tCO2e/MMBTU when replacing coal combustion, based on CCS standards used in the inventory and forecast.

*Biomass Costs*

The cost analysis for this option is based on the difference in costs between supply of woody biomass fuel and the assumed fossil fuel that it is replacing. The assumed costs and the source of the costs are identified in table X below.

**Table X: Assumed Costs of Feedstocks**

| Fuel Type | Cost $/ton delivered | Cost $/MmBtu | Source |
|---|---|---|---|

[41] Assumed heat content of Ag Byproducts of 8.25 MBtu/Ton, Sourced from EIA Average Heat Content of Selected Biomass Fuels http://www.eia.doe.gov/cneaf/solar.renewables/page/trends/table10.html

[42] Based on the La Capra Associates and GDS Associates report, the technical potential MW calculation assumes direct-fired plants with 14,000 btu/kWh heat rate and a capacity factor of 85%.

[43] Based on the La Capra Associates and GDS Associates report, the assumed heat content of wood biomass material is 8,500 btu/dry lb of biomass. Potential MW calculation assumes direct-fired plants with 14,000 btu/kWh heat rate and a capacity factor of 85%.

| | | delivered | |
|---|---|---|---|
| Agricultural Byproducts | ? | ? | |
| Wood Biomass | $ 65.00 | $ 4.00 | La Capra Associates and GDS Associates. 2007. "Analysis of Renewable Energy Potential in South Carolina." Prepared for: Central Electric Power Cooperative Inc. September 12, 2007. Accessed on January 8, 2008 from: http://www.ecsc.org/newsroom/RenewablesStudy.ppt. |
| SwitchGrass | ? | ? | |
| Bituminous Coal | $34.26 | $ 1.53 | Source: EIA Coal Prices Fact sheet http://www.eia.doe.gov/neic/infosheets/coalprice.html |

The cost is calculated by assuming the replacement of coal with biomass as indicated in Table X in MBtu. The difference in cost of supply between biomass and coal is calculated using the costs above. The difference in costs ($/MBtu) is multiplied by the amount of coal energy (MBtu) being replaced by biomass. A summary of avoided emissions and cost for each year for agriculture residue, switchgrass and wood biomass are presented in Tables X,Y and Z.

**Table X: Summary of Agriculture Residue Biomass GHG Benefits and Costs**

| Year | Percent of Utilization | Ag Residue Biomass (MMBtu) | Approximate Electrical Capacity (MW) | Avoided Emissions Ag Residue (MtCO2-e) | Ag Residue Cost/Savings | Discounted Cost/Savings |
|---|---|---|---|---|---|---|
| 2008 | 3% | 611,156 | 6 | 0.057 | | |
| 2009 | 7% | 1,222,312 | 12 | 0.115 | | |
| 2010 | 10% | 1,833,468 | 18 | 0.172 | | |
| 2011 | 12% | 2,200,161 | 21 | 0.207 | | |
| 2012 | 14% | 2,566,855 | 25 | 0.241 | | |
| 2013 | 15% | 2,818,957 | 27 | 0.265 | | |
| 2014 | 17% | 3,071,059 | 29 | 0.289 | | |
| 2015 | 18% | 3,323,161 | 32 | 0.312 | | |
| 2016 | 20% | 3,575,262 | 34 | 0.336 | | |
| 2017 | 21% | 3,827,364 | 37 | 0.360 | | |
| 2018 | 22% | 4,079,466 | 39 | 0.384 | | |
| 2019 | 24% | 4,331,568 | 42 | 0.407 | | |
| 2020 | 25% | 4,583,670 | 44 | 0.431 | | |
| | | | Cumulative | **3.03** | | ? |

**Table Y: Summary of Switchgrass GHG Benefits and Costs**

| Year | Percent of Utilization | Total Energy Crops (MMBtu) | Approximate Electrical Capacity (MW) | Avoided Emissions, Energy Crops | Ag Residue Cost/ Savings | Discounted Cost/ Savings |
|---|---|---|---|---|---|---|

| | | | | (MtCO2e) | | |
|---|---|---|---|---|---|---|
| 2008 | 3% | 559,697 | 5 | 0.053 | | |
| 2009 | 7% | 1,119,395 | 11 | 0.105 | | |
| 2010 | 10% | 1,679,092 | 16 | 0.158 | | |
| 2011 | 12% | 2,014,910 | 19 | 0.189 | | |
| 2012 | 14% | 2,350,729 | 23 | 0.221 | | |
| 2013 | 15% | 2,581,604 | 25 | 0.243 | | |
| 2014 | 17% | 2,812,479 | 27 | 0.264 | | |
| 2015 | 18% | 3,043,354 | 29 | 0.286 | | |
| 2016 | 20% | 3,274,229 | 31 | 0.308 | | |
| 2017 | 21% | 3,505,104 | 34 | 0.329 | | |
| 2018 | 22% | 3,735,979 | 36 | 0.351 | | |
| 2019 | 24% | 3,966,854 | 38 | 0.373 | | |
| 2020 | 25% | 4,197,730 | 40 | 0.394 | | |
| | | | **Cumulative** | **3.27** | | |

**Table Z: Summary of Wood Biomass GHG Benefits and Costs**

| Year | Percent of Utilization | Forest Residue Biomass (MMBTU) | Approximate Electrical Capacity (MW) | Avoided Emissions Forest Residue (MMtCO2-e) | Forest Residue Cost/ Savings | Discounted Cost/ Savings |
|---|---|---|---|---|---|---|
| 2008 | 3% | 5,555,083 | 53 | 0.522 | $ 13,721,054 | $12,445,401 |
| 2009 | 7% | 11,110,165 | 107 | 1.04 | $ 27,442,108 | $23,705,525 |
| 2010 | 10% | 16,665,248 | 160 | 1.57 | $ 41,163,162 | $33,865,036 |
| 2011 | 12% | 19,998,297 | 192 | 1.88 | $ 49,395,795 | $38,702,898 |
| 2012 | 14% | 23,331,347 | 224 | 2.19 | $ 57,628,427 | $43,003,220 |
| 2013 | 15% | 25,622,819 | 246 | 2.41 | $ 63,288,362 | $44,977,857 |
| 2014 | 17% | 27,914,290 | 268 | 2.62 | $ 68,948,297 | $46,666,921 |
| 2015 | 18% | 30,205,762 | 290 | 2.84 | $ 74,608,232 | $48,093,131 |
| 2016 | 20% | 32,497,233 | 312 | 3.05 | $ 80,268,167 | $49,277,691 |
| 2017 | 21% | 34,788,705 | 334 | 3.27 | $ 85,928,101 | $50,240,381 |
| 2018 | 22% | 37,080,177 | 356 | 3.48 | $ 91,588,036 | $50,999,646 |
| 2019 | 24% | 39,371,648 | 378 | 3.70 | $ 97,247,971 | $51,572,675 |
| 2020 | 25% | 41,663,120 | 400 | 3.92 | $ 102,907,906 | $51,975,485 |
| | | | **Cumulative** | **32.5** | | $545,525,867 |

**Key Assumptions: [**TBD, as needed on TWG approval]

## Key Uncertainties

TBD – [as needed and approved by the TWGs]

## Additional Benefits and Costs

TBD – [as needed and approved by the TWGs]

## Feasibility Issues

TBD – [as needed and approved by the TWGs]

## Status of Group Approval

Pending – [until CECAC moves to final agreement at meeting #5 or #6]

## Level of Group Support

TBD – [blank until CECAC meeting #5]

## Barriers to Consensus

TBD – [blank until final vote by the CECAC] Sample Draft Policy Option Template

# AFW-6. Terrestrial Carbon Sequestration

## AFW-6(a). Soil Carbon Management (Agriculture)

### Policy Description

There are four components of soil carbon management considered in this option: alternative cultivation practices (conservation-till, no-till, bio-char application, compost application, cover crops, etc.), manure management practices, crop conversion to increase sequestration potential, and rotational grazing.

The amount of carbon stored in the soil can be increased by the adoption of practices such as conservation and no till cultivation, cover cropping, and application of biochar and compost. Reducing summer fallow and increasing winter cover crops are complimentary practices that reduce the need for conventional tillage. The application of biochar (i.e., charcoal) and compost increases soil carbon content, stabilizes soil carbon, enhances drought resistance, and may improve production by boosting soil dynamics. By reducing mechanical soil disturbance, these practices reduce the oxidation of soil carbon compounds and allow more stable aggregates to form. Other benefits include reduced wind and water erosion, reduced fuel consumption, and improved wildlife habitat.

Additionally, the implementation of manure management practices may reduce GHG emissions associated with manure handling and storage. Potential practices include but are not limited to composting of manure (to reduce methane emissions) and improved methods of field-application (for reduced nitrous oxide emissions). Application improvements include incorporation into soil, instead of surface spray/spreading, spreader calibration, and manure-management planning.

Convert marginal agricultural land used for annual crops to permanent cover such as grassland/rangeland, orchard, perennial bio-crops, or forest, where the soil carbon and/or carbon in biomass is higher under the new land use. This option includes opportunities to keep CRP lands covered in perpetuity. Increased demand for corn-based ethanol and biodiesel feedstocks can act as an incentive for converting grassland to cropland. Adopt incentives to reduce acreage returning to conventionally tilled production or to suburban/urban development.

Heavy grazing can cause significant soil disturbance and result in carbon losses from soils. Rotational grazing where animals are moved from field-to-field on a regular basis reduces soil disturbance and improves soil carbon levels. Rotational grazing also can improve plant vigor.

### Policy Design

**Goals:** By 2020, apply improved soil carbon management practices on 50% of acres that currently do not use these practices (see definition of improved soil carbon management practices in “Policy Description,” above). Note to TWG: need to consider a separate goal for manure management, as this element does not fit into the existing goal structure.

**Timing:** By 2012, apply improved soil carbon management practices on 20% of acres that currently do not use these practices. Achieve an increase to 50% of these acres by 2020.

**Parties involved:** SC Department of Agriculture; SC DNR – Conservation Districts; Clemson University – Cooperative Extension Service; USDA – Natural Resources Conservation Service; SC Farm Bureau; Farmers.

**Other:** Note to TWG: CECAC would like to see information on baselines to better understand the goals (e.g. current acres that utilize the above practices). Studies in North Carolina have found the potential to sequester one ton of carbon per acre through conservation tillage / no-till practices over a six-year period[44] (equivalent to about 3.3 $MtCO_2e$/acre). Studies in California[45] and Pennsylvania[46] have shown that improved soil carbon management techniques (i.e., cover cropping and application of compost and manure) can sequester dramatically more carbon than no-till practices alone. Moreover, it appears that the sequestration benefits of no-till are limited, whereas the longitudinal study in Pennsylvania saw no less accumulation of soil carbon sequestration over the 25 year period. *Are we inferring that accumulations occur indefinitely*?

Different methods to increase soil carbon content have different effects on soil fertility, disease management, and actual sequestration. Also, certain soil carbon management techniques may require greater energy input than others. Additionally, crop production cycle GHG emissions have not been quantified for all these improved soil carbon management practices. For these reasons, in-state research studies are needed to determine the optimal soil carbon management techniques in South Carolina's various soils, with the greatest GHG benefits.

## Implementation Mechanisms

TBD – [CCS drafts based on TWG inputs; this can be developed as they go along, and can start early or late as they prefer; the level of detail can vary on TWG approval]

## Related Policies/Programs in Place

Many farmers are participating in the no-till program. Each farm is eligible for up to $40,000 per year (max. 3 years) in fixed-rate incentives for participating in no-till farming of low-residue crops such as tobacco, vegetable crops, peanuts, cotton, soybeans, and silage crops.

Comprehensive Nutrient Management Plans are required, and some have been submitted to the Department. Regulation mandates that manure is applied at agronomic rates and that spreaders are calibrated. Many farms have composters for dead bird disposal. Some manure is used in this

[44] Source: http://southeastfarmpress.com/news/030106-Naderman-conservation/

[45] Source: "Conservation tillage and cover cropping influence soil properties in San Joaquin Valley cotton-tomato crop," by Jessica J. Veenstra, William R. Horwath, Jeffrey P. Mitchell and Daniel S. Munk. California Agriculture Journal, July-Sept. 2006. http://calag.ucop.edu/0603JAS/pdfs/ConservTillageTomato.pdf

[46] "The Rodale Institute Farming Systems Trial 1981 to 2005: Long Term Analysis of Organic and Conventional Maize and Soy-bean Cropping Systems," p15-30, in Long Term Field Experiments in Organic Farming, edited by J Rauppe, C Perkrun, M Oltmanns, U Kopke. ISOFAR International Society of Organic Agriculture Research, Verlaug Publishing, Berlin, 2006.

process. Composted material is applied at agronomic rate. Because of the high cost of commercial fertilizer, many farms are getting their land approved for manure applications.

Cost-sharing programs available for landowners to manage forestland. These include the Forest Renewal Program, Stewardship Incentives Program, Conservation Reserve Program, Forest Land Enhancement Program, Wildlife Habitat Incentive Program, Environmental Quality Incentive Program, and others. Through these programs landowners can receive advice from foresters, biologists, soil scientists, and other experts along with cost sharing that pays, on average, about 40% of the cost of site preparation, planting, soil stabilization, wildlife habitat improvement, and some intermediate management practices.

## Type(s) of GHG Reductions

**$CO_2$:** Reducing tillage and soil disturbance slows the breakdown of plant material on the soil surface and in the root zone, accelerating the microbial processes that stabilize carbon and protecting carbon from oxidation, inhibiting the release of carbon back into the atmosphere. Depending on how the adoption of alternative cultivation methods affects the overall crop production cycle, additional $CO_2$ reductions can occur through lower fossil fuel consumption in farm equipment. The conversion of agricultural lands to grassland cover, as well as the implementation of rotational grazing will increase terrestrial carbon sequestration.

**$N_2O$:** To the extent that fossil fuel consumption is lowered through the cultivation methods implemented under this policy, $N_2O$ emissions from fuel combustion will be lowered. It is important to note that research also indicates the potential for higher $N_2O$ emissions as soil organic carbon levels increase.[47] Nutrient management programs that reduce the application of manure and fossil-derived fertilizers reduce emissions that occur as a result of nitrogen run-off and leaching.

**$CH_4$:** To the extent that fossil fuel consumption is lowered through the cultivation methods implemented under this policy, $CH_4$ emissions from fuel combustion will be lowered. More efficient applications of manure (or other organic fertilizers) have the potential to reduce methane emissions.

Also, full life-cycle analysis on crop inputs is needed: For examples, displacement of chemical inputs through the use of bio-char, compost, manure, cover-cropping, or mechanical weed control will reduce emissions of fossil CO2 associated with manufacture of these chemical inputs.

## Estimated GHG Reductions and Net Costs or Cost Savings

TBD – [CCS should provide a worksheet and other reference material as needed for transparency]

**Data Sources: [**TBD by CCS on TWG approval]

[47] Li et al., “Carbon Sequestration in Arable Soils is Likely to Increase Nitrous Oxide Emissions, Offsetting Reductions in Climate Radiative Forcing,” *Climate Change* (2005) 72:321–338.

**Quantification Methods:**

*GHG Benefits*

The quantification of the GHG benefits of this option will follow the following process:

- Determine how many acres are currently using the practices designed as "improved soil carbon management practices." TWG will need to provide input as to which carbon management strategies are complementary and which strategies are to be used independently (i.e. can no-till and manure management apply to the same land?). This will likely take some off-line discussion with CCS and TWG members.

*Cost Effectiveness*

Pending resolution of above questions.

**Key Assumptions: [**TBD, as needed on TWG approval]

## Key Uncertainties

TBD – [as needed and approved by the TWGs]

## Additional Benefits and Costs

TBD – [as needed and approved by the TWGs]

## Feasibility Issues

TBD – [as needed and approved by the TWGs]

## Status of Group Approval

Pending – [until CECAC moves to final agreement at meeting #5 or #6]

## Level of Group Support

TBD – [blank until CECAC meeting #5]

## Barriers to Consensus

TBD – [blank until final vote by the CECAC]

## AFW 6(b). Forest Management for Carbon Sequestration

### Policy Description

Forest management has significant potential to sequester carbon dioxide. Southern forests are capable of sequestering more than one metric ton of CO2 per acre every year, and there are 12.7 million acres of forest land in SC. Since 73% of SC forest land is privately owned, the management decisions made by private landowners will ultimately determine carbon impacts.

Promoting Forest Management for Carbon Sequestration also confers many additional benefits such as wildlife habitat, clean air and water, recreational opportunities, and scenic quality. Timber is SC's highest valued agricultural crop, and forest industry is among the top manufacturing segments. Forest-based jobs, payroll, and capital investment are an important part of the state's economy.

This option includes a range of forest management activities that promote productivity and increase the rate of carbon dioxide sequestration in biomass, soils, and in harvested wood products. Practices may include: increased stocking of poorly stocked lands, age extension of managed stands, thinning and density management, fertilization and waste recycling, expanding short rotation woody crops (for fiber and energy), expanded use of genetically preferred species, modified biomass removal practices, fire management and risk reduction, pest and disease management.

Establish forests on land that has not historically been forested (e.g., agricultural land) ("afforestation"). Promote forest cover and associated carbon stocks by regenerating or establishing forests in areas with little or no present forest cover ("reforestation"). In addition, implement practices such as soil preparation, erosion control, and stand stocking to ensure conditions that support forest growth. These practices should also include urban forestry, including urban tree planting and enhanced maintenance programs.

### Policy Design

**Goals:** By 2020, ensure reforestation of 1.4 million acres by 2020 by planting approximately 120,000 acres annually; increase the number of landowners with a forest management plan by 50%; double the number of Tree Cities USA to 80 in SC; and achieve 40% canopy cover in 50% of municipalities.

> *Forest Management:* By 2020, apply improved forest management practices on 50% more acres than currently use these practices (see definition of improved forest management practices in "Policy Description," above).
>
> *Reforestation:* Reforest 100% of Forestland identified as suitable for reforestation*;* ensure reforestation of 1.4 million acres by 2020 by planting approximately 120,000 acres annually*;*
>
> *Urban Forestry:* Achieve 40% tree cover over all zones by 2020. Zone-specific goals include 50% tree cover in suburban residential zones, 25% tree cover in urban residential

zones, and 15% tree cover in central business districts.[48] Double the number of municipalities participating in the Tree City USA program by 2020.

**Timing:**

*Forest Management:* By 2012, apply improved forest management practices on 20% more acres than currently use these practices. Achieve an increase to 50% by 2020.

*Reforestation:* By 2008, complete survey of SC Forestland to identify lands suitable for reforestation. Complete 25% of reforestation efforts by 2012.

*Urban Forestry:* Achieve 25% of goals by 2012.

**Parties Involved:** SC Forestry Commission, SC Forestry Association, SC Parks Recreation & Tourism, SC Department of Natural Resources, SC Conservation Bank, SC Department of Agriculture, Santee Cooper, SC Farm Bureau, US Fish & Wildlife Service, US Forest Service, US Park Service, Clemson University, NGOs (including but not limited to SC Forestry Association, Ducks Unlimited, The Nature Conservancy, Lowcountry Open Land Trust, Congaree Land Trust, etc.)

**Other:** Not Identified

## Implementation Mechanisms

Emphasis of opportunities to voluntarily optimize forest productivity by increasing forest stand density thereby sequestering additional carbon; exploration of opportunities to reward forest landowners with tax credits for increasing carbon sequestration on privately owned forest lands [Note to TWG: this has been moved to AFW-6b under Forest Management program implementation from AFW-7b implementation mechanisms.]

Considerations include:

1) Increase productivity of forest land and encourage active management of of privately owned lands through increased availability of technical assistance, cost-sharing programs, and education/outreach for landowners.

2) Fully fund and expand existing reforestation programs such as the Forest Renewal Program and Grow Some Green in order to promote afforestation and reforestation.

3) Promote carbon markets to provide financial incentives for landowners to enhance carbon sequestration through forest management. Consider development of a state carbon registry and explore markets for trading carbon offsets.

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[48] These goals are consistent with the "Urban Tree Canopy Goals" established by American Forests. Accessed on January 2, 2008 from: http://www.americanforests.org/resources/urbanforests/treedeficit.php.

4) Support a healthy forest industry in South Carolina to ensure strong markets for primary forest products grown in-state. Emphasize forest-based economic development in rural areas, and encourage consumers to purchase SC grown and manufactured wood and paper products. Establish preference for SC products in government procurement. Strong markets for forest products will ensure that forest management is a financially sustainable option for private landowners.

5) Provide services for forest protection to minimize losses to wildfire, insects, disease, and invasive species.

6) Promote urban and community forestry programs leading to increased energy savings. Increase grant funding available to municipalities through the SC Forestry Commission Urban and Community Forestry program.

## Related Policies/Programs in Place

Assistance available to pay partial costs of prescribed burning, reforestation, stand improvement, and other practices. Some poultry litter and municipal sludge are utilized as forest fertilizer. 21,000 acres of forestland will be included in a program to restore the longleaf pine. SC will implement the use of improved seedlings for higher production. For example, Arborgen and Cellfor are developing tree varieties to capture more carbon. SC forestry commission offers assistance and guidance for those seeking to perform prescribed burns to mitigate wildfire risk. Programs such as “Firewise Communities” educate homeowners about wildfire prevention and provide wildfire hazard assessments. There is a current USFS program for reducing wildfire hazard and putting the biomass toward beneficial use.

SC Forestry Commission uses several state and federal cost-share programs and technical assistance for landowners.

Tree City USA is a program sponsored by the National Arbor Day Foundation that provides direction, technical assistance, and publicity for urban and community forestry programs. Currently, 40 SC cities are participating in the Tree City USA program.

## Type(s) of GHG Reductions

**$CO_2$:** Carbon sequestration from new forest growth. Sequestration in durable wood products and fossil fuel offsets from forest based energy (not quantified, outside of analysis period). Prevention of emissions from forest conversions and improved retention of soil carbon over agriculture

## Estimated GHG Reductions and Net Costs or Cost Savings

### *Forest Management*

**Data Sources:** Forest carbon stocks, sequestration rates, and growing stock volume from Southeast US defaults in the US Forest Service Methods for Calculating Forest Ecosystem and Harvested Carbon with Standards Estimates for Forest Types of the US, General Technical Report NE-343 (also published as part of the Department of Energy Voluntary GHG Reporting Program); data on distribution of forest types in SC from USFS Forest Inventory Analysis;

Assumptions about carbon removals during harvesting from Strong, T.F., 1997 "Harvesting Intensity Influences the Carbon Distribution in a Northern Hardwood Ecosystem," USFS Research Paper NC-329; costs of implementing forest management practices based on similar estimates for North Carolina; National Woodland Owner Survey (can I get a copy from G. Sabin?); harvest rates calculated from data published in South Carolina Forest Resources – 2000 Update (USFS Resource Bulleting SRS-65).

**Quantification Methods:**

*Forestland Targeted for Improved Forest Management*

Twenty-eight percent of private forest land owners in SC report receiving some form of assistance to improve their forest management (National Woodland Owner Survey, personal communication G. Sabin). The goal of this option is to increase the number of landowners (and the acres they manage) that receive such assistance. In 2006, SC had 4,750,214 acres of privately owned Loblolly-shortleaf pine forestland (FIA 2006). As noted below, the analysis is limited to Loblolly-shortleaf because this is a predominant forest type and the appropriate data are available for this type only. It is roughly estimated that about twenty-eight percent of these acres, or 1,330,060 acres, are under some form of active/improved management currently in SC. Thus, under the goals of this option, by 2012, an additional 266,012 acres would be under improved forest management and by 2020, an additional 665,030 acres would be under improved forest management. To achieve these cumulative levels, approximately 66,503 acres per year from 2009-2012 and 49,877 acres per year from 2013-2020 would need to move from average or below average conditions to improved management.

*Impacts of Improved Management on Carbon Sequestration*

Net changes in carbon stocks in forest biomass and soil are influenced by growth, mortality and decay processes, as well as the amount of carbon removed during harvest, all of which are influenced by forest management to some degree. A range of forest management activities can promote productivity and increase the rate of carbon sequestration in SC (see Policy Option Description for details). Increasing productivity involves increasing the rate at which forests accumulate biomass; i.e., a high productivity stand accumulates more carbon in biomass over the same amount of time as an otherwise equivalent low productivity stand. This leads to a relatively higher growing stock volume (i.e., the volume of living trees above the ground), some portion of which is harvested at periodic intervals (providing for potentially greater harvest volumes).

Data are available to estimate the carbon stock and growing stock volume changes associated with increasing productivity of Loblolly-shortleaf pine stands in SC. In addition, Loblolly-shortleaf pine forests are the most abundant type in SC, making up 41% of all classes of forest and 42% of all privately owned forests in SC (FIA 2006). An analysis of this forest group alone is believed to be a good approximation of the overall potential GHG benefits of forest management in SC. Thus, the analysis below is based on shifting productivity levels from average or below average to high levels in privately owned Loblolly-shortleaf stands.

The estimated changes are based on comparing carbon and growing stock volume yield tables for average and high productivity Loblolly-shortleaf pine stands in the Southeast published by the USFS. This type of comparison assumes that the newly treated stands will realize gains as if they were growing according to the yield table of a high producing forest from their beginning.

In reality, total gains will be influenced by the age of the stand at which time treatment is initiated.

The net impact of a shift from low to high productivity forests involves both forest carbon and HWP pools. From a carbon accounting perspective, harvested carbon represents a carbon stock loss to the forest and a carbon stock gain into the HWP pool, with only a portion of the carbon that is shifted into the HWP pool at harvest remaining stored for long periods of time. The change in carbon stocks in both forest and HWP pools are quantified below.

*Estimated Increases in Carbon Sequestration Rates and Growing Stock Volumes*

The USFS publishes carbon stock tables for forest types by region for the entire US. In some regions, for some forest types, the USFS provide tables for both average and high productivity stands. Such tables are available for Loblolly-shortleaf pine in the Southeast. Carbon stock and growing stock volume data in the USFS tables (see Tables 1a and 1b below) were used to calculate an annual carbon sequestration rate for average and high productivity Loblolly-shortleaf pine forests in SC (carbon stocks in 30 yr old stands were subtracted from carbon stocks in new stands and divided by 30). An average over 30 years is assumed to encompass the range of age classes for this forest type given that about 75% of all Loblolly-shortleaf pine stands in 2006 were 30 years or younger according to FIA data (in reality, sequestration rates vary by stand age). Note that soil carbon stocks are constant over time and between productivity classes, so carbon stock gains occur only in biomass pools. Comparing Tables 1a and 1b below shows that high productivity stands sequester approximately 0.9 tons more carbon per acre per year. Therefore, regardless of the initial carbon stock levels, a forest stand that moves to higher productivity status will gain roughly 0.9 more tons C per acre per year than it would if left as is.

**Table. 1a Carbon stocks and mean growing stock volumes by selected age class for Loblolly-shortleaf pine in the Southeastern US (USFS GTR NE-343, Table A39)**

| Age | Mean volume (cf/ac) | Biomass (tC/ac) | Soils (tC/ac) | Total (tC/ac) |
|---|---|---|---|---|
| 0 | 0 | 10.7 | 29.5 | 40.2 |
| 30 | 1554 | 32.7 | 29.5 | 62.2 |
| Average annual sequestration (30 year average) (tC/ac/yr) | | | | 0.73 |

**Table. 1b Carbon stocks and mean growing stock volumes by selected age class for high productivity sites (growth rates greater than 85 cubic feet/ac/yr), with high-intensity management (replanting with genetically improved stocks) (USFS GTR NE-343, Table A40)**

| Age | Mean volume (cf/ac) | Biomass (tC/ac) | Soils (tC/ac) | Total (tC/ac) |
|---|---|---|---|---|
| 0 | 0 | 14.9 | 29.5 | 44.4 |
| 30 | 4963 | 64.6 | 29.5 | 94.1 |
| Average annual sequestration (30 year average) (tC/ac/yr) | | | | 1.66 |

In addition, the growing stock volume is greater in all age classes of high productivity stands. Assuming that, on average, stands are harvested at 30 yrs, USFS HWP accounting methods were used to convert the 3,409 cubic feet per acre incremental increase in growing stock volume into the equivalent carbon volume of 35.6 tons C/ac (see Table A2 and Appendix below for explanation of this calculation). Note that this is the carbon stored in the incremental increase in growing stock, only a portion of which is removed during harvest (this analysis assumes 35% is removed, see below).

*Calculation of Net Carbon Stock Change in Forests and HWP*

The calculation of net forest carbon stock change takes into account that each year gains in biomass carbon stocks from higher accumulation rates are offset by the removal of larger volumes of carbon during harvest (Table 3). The incremental increase in biomass carbon stocks is calculated by multiplying the cumulative number of acres treated by 0.9 tons C/ac/yr (Table 3, Column A). Cumulative acres are used because once an area is treated it continues to sequester carbon at a higher rate in subsequent years.

The incremental increase in carbon removed during harvest is calculated by multiplying the number of acres harvested each year by 35% of the carbon increase in growing stock volume (i.e., 35% of 35.6 tons C/a = 12.5 tons C/ac) (Table 3, Column B). This assumes that 35% of the growing stock volume is removed during a harvest (based on a study of carbon removals at different harvest levels; 35% is roughly the proportion removed from moderate harvest levels, see Strong 1997 for details). The number of acres harvested is calculated by assuming 1.66% of the acres treated each year are harvested the following year. The harvest rate of 1.66% was calculated from data published in the South Carolina Forest Resources – 2000 Update (USFS Resource Bulleting SRS-65).

Carbon removed during harvest is subtracted from the carbon gains in biomass due to sequestration to yield a net change in forest carbon stocks each year (Table 3, Column C). If the calculation stopped here, then this would imply that all carbon removed is essentially emitted to the atmosphere. Therefore, a subsequent step is taken to account for the portion of carbon that remains stored in HWP for a total carbon stock balance.

Standard USFS HWP accounting methods were used to estimate the incremental increase in harvested carbon that remains stored in HWP indefinitely. The amount of carbon stored in HWP carbon stocks is time dependent relative to the year of harvest (carbon stocks are high initially and decrease over time as a result of disposal and decay), making carbon stock accounting for HWP complex. Therefore, an approach has been developed to standardize and simplify HWP carbon accounting, which applies the amount of carbon still stored in HWP 100-yrs after harvest as the estimated net increase in HWP carbon stocks; and, this gain is attributed to the year of harvest.

The USFS methods were applied to coefficients for Loblolly-shortleaf pine stands in the Southeast to estimate that approximately 21% of harvested carbon remains stored in HWP 100-yrs after harvest (see Table A5 and Appendix below for calculation details). Therefore, the long-term storage of carbon in HWP increases by approximately 2.6 tons C/ac when stands go from average to high productivity forests (i.e., an additional 12.5 tons C/ac is harvested, of which 21% remains stored indefinitely). The net carbon stock increase in HWP attributable to increased productivity was calculated by multiplying the number of acres harvested by 2.6 tons C/acre (Table 3, Column D). For standardization across all policy options, units are converted to million metric tons carbon dioxide equivalent (MMtCO2e) in Table 4.

**Table 3. Summary of Calculated Net Changes in Forest and HWP Carbon Stocks (in units of tons C)**

| Year | Acres/yr | Cumulative Acres | **Column A** Increased C Stocks in Forest Biomass (tons C) | **Column B** Increased C Stocks Removed at Harvest (tons C) | **Column C (A minus B)** Net Change in Forest Carbon Stocks (tons C) | **Column D** Net Increase in HWP C Stocks (tons C) | **Column E (C plus D)** Total Increase in Forest and HWP Carbon (tons C) |
|---|---|---|---|---|---|---|---|
| 2009 | 66,503 | 66,503 | 61,404 | 0 | 61,404 | 0 | 61,404 |
| 2010 | 66,503 | 133,006 | 122,809 | 13,752 | 109,057 | 2,872 | 111,928 |
| 2011 | 66,503 | 199,509 | 184,213 | 13,752 | 170,461 | 2,872 | 173,333 |
| 2012 | 66,503 | 266,012 | 245,618 | 13,752 | 231,866 | 2,872 | 234,737 |
| 2013 | 49,877 | 315,889 | 291,671 | 13,752 | 277,919 | 2,872 | 280,791 |
| 2014 | 49,877 | 365,766 | 337,724 | 10,314 | 327,410 | 2,154 | 329,564 |
| 2015 | 49,877 | 415,644 | 383,778 | 10,314 | 373,464 | 2,154 | 375,617 |
| 2016 | 49,877 | 465,521 | 429,831 | 10,314 | 419,517 | 2,154 | 421,671 |
| 2017 | 49,877 | 515,398 | 475,884 | 10,314 | 465,570 | 2,154 | 467,724 |
| 2018 | 49,877 | 565,275 | 521,938 | 10,314 | 511,624 | 2,154 | 513,777 |
| 2019 | 49,877 | 615,153 | 567,991 | 10,314 | 557,677 | 2,154 | 559,831 |
| 2020 | 49,877 | 665,030 | 614,044 | 10,314 | 603,730 | 2,154 | 605,884 |
| Total | 665,030 | | | | 4,109,698 | 26,564 | 4,136,263 |

**Table 4. Summary Table: Results in Million Metric Tons Carbon Dioxide Equivalent (MMtCO2e)**

| | Net Change in Forest Carbon Stocks (MMtCO2e) | Net Increase in HWP C Stocks (MMtCO2e) | Total Increase in Forest and HWP Carbon (MMtCO2e) |
|---|---|---|---|
| 2009 | 0.23 | 0.00 | 0.23 |
| 2010 | 0.40 | 0.01 | 0.41 |
| 2011 | 0.63 | 0.01 | 0.64 |
| 2012 | 0.85 | 0.01 | 0.86 |
| 2013 | 1.02 | 0.01 | 1.03 |
| 2014 | 1.20 | 0.01 | 1.21 |
| 2015 | 1.37 | 0.01 | 1.38 |
| 2016 | 1.54 | 0.01 | 1.55 |
| 2017 | 1.71 | 0.01 | 1.71 |
| 2018 | 1.88 | 0.01 | 1.88 |
| 2019 | 2.04 | 0.01 | 2.05 |
| 2020 | 2.21 | 0.01 | 2.22 |
| Total | 15.07 | 0.10 | 15.17 |

The results suggest potential net carbon stock increases in forest biomass of 0.85 MMtCO2e in 2012, increasing to 2.21 MMtCO2e in 2020 as more acres are treated, with a cumulative gain in forest biomass carbon stocks of 15.07 MMtCO2e from 2009-2020. In addition, the analysis suggests a relatively small net carbon stock increase in HWP of 0.01 MMtCO2e each year starting in 2010, for a cumulative gain of 0.10 MMtCO2e from 2009-2020.

**Costs Analysis**

In this analysis costs are based on the average cost of implementing forest management practices on the ground that have the potential to increase productivity. These data are readily available from existing technical assistance programs.

An average lifetime cost to implement forest management practices was estimated to be $264/acre based on data used in a similar analysis for North Carolina (where it was assumed that forest management costs about $8.80 per acre for 30 years).

The average cost to implement forest management was multiplied by the number of acres treated each year to yield an average annual cost (Table 5). Annual discounted costs were estimated each year from 2009 to 2020 using a 5% discount rate. The sum of annual discounted costs from 2009 to 2020 provides an estimate of the Net Present Value (NPV) of this option, which amounts to $139 million. The cumulative cost effectiveness of the total program was calculated by dividing the NPV by cumulative carbon benefits of this option for, yielding $9/ton CO2e.

**Table 5: Summary of Cost and Cost Effectiveness**

| | Acres | Total GHG Benefit (from Table 4) | Cost | Discounted Costs |
|---|---|---|---|---|
| 2009 | 66,503 | 0.23 | $17,556,791 | $17,556,791 |
| 2010 | 66,503 | 0.41 | $17,556,791 | $16,720,754 |
| 2011 | 66,503 | 0.64 | $17,556,791 | $15,924,527 |
| 2012 | 66,503 | 0.86 | $17,556,791 | $15,166,217 |
| 2013 | 49,877 | 1.03 | $13,167,594 | $10,833,012 |
| 2014 | 49,877 | 1.21 | $13,167,594 | $10,317,154 |
| 2015 | 49,877 | 1.38 | $13,167,594 | $9,825,861 |
| 2016 | 49,877 | 1.55 | $13,167,594 | $9,357,963 |
| 2017 | 49,877 | 1.71 | $13,167,594 | $8,912,346 |
| 2018 | 49,877 | 1.88 | $13,167,594 | $8,487,948 |
| 2019 | 49,877 | 2.05 | $13,167,594 | $8,083,760 |
| 2020 | 49,877 | 2.22 | $13,167,594 | $7,698,819 |
| Total | 665,030 | 15.17 | | $138,885,152 |

The analysis does not account for potential increases in forest revenue as a result of greater harvest volumes and a strong forest products markets. If this were taken into account, the net costs of the option would be lower or possibly even negative.

**Appendix: Calculations of HWP assumptions**

Two key HWP coefficients were calculated using standard USFS methods:

- incremental increase in carbon in the growing stock volume of forests treated to improve productivity (35.6 tons C/ac, see Table A2)
- of this, the amount of that carbon that remains stored in products in use and landfills 100-years after harvests (7.4 tons C/ac, or 21% of 35.6 tons C/ac, see Table A5)

The USFS methodology uses growing stock volume in metric units as a starting point. The incremental increase in growing stock volume of high productivity stands was used as a starting point for this analysis: 3,409 cubic feet per acre converts to 235 cubic meters per hectare (m3/ha). Thus, all factors calculated below represent increases above baseline productivity levels.

A series of default coefficients for the Southeast region were applied to the increase of 235 m3/ha, to apportion the fraction of growing stock volume into classes of softwoods and hardwoods (Table A1). The specific gravity of hardwoods and softwoods are combined with the carbon content in biomass to calculate separate per-area carbon volumes for hardwood and softwood classes (Table A2).

**Table A1. Softwood and Hardwood fractions in the growing stock volume, for Loblolly-shortleaf stands in the Southeast (US GTR NE-343 Table 4)**

| | Factor |
|---|---|
| Incremental increase in growing stock volume (m3/ha) (i.e., 3,409 cuft/ac converted to metric units) | 235 |
| Fraction of growing stock volume that is softwood | 0.880 |
| Fraction of softwood growing stock volume that is sawtimber-size | 0.653 |
| Fraction of hardwood growing stock volume that is sawtimber-size | 0.358 |
| Specific gravity of softwoods | 0.470 |
| Specific gravity of hardwoods | 0.516 |
| Carbon content in biomass | 0.5 |

**Table A2. Calculated Carbon Content of Softwood and Hardwoods Harvested from Loblolly-shortleaf stands in the Southeast**

| | Tons C/ha |
|---|---|
| Softwood saw log carbon in growing-stock volume | 31.67 |
| Softwood pulpwood carbon in growing-stock volume | 48.50 |
| Hardwood saw log carbon in growing-stock volume | 2.60 |
| Hardwood pulpwood carbon in growing-stock volume | 4.66 |
| Total (tons C/ha) | 87.43 |
| Total (tons C/ac) | 35.58 |

The quantity of carbon in hardwoods and softwoods that is processed into primary wood products was calculated next (factoring out carbon in logging residue, fuelwood, and waste), using the ratios in Table A3 for the South. The results are approximate per-area carbon stocks (tons carbon per hectare) in industrial roundwood, excluding bark and fuelwood (Table A4).

**Table A3. Ratios of Industrial Roundwood produced from Hardwood and Softwood classes in the Southern Region of the US (USFS GTR NE-343 Table 5)**

| | Ratio of industrial RW to growing stock volume removed as RW | Ratio of carbon in bark to carbon in wood | Fraction of growing stock volume removed as roundwood | Ratio of fuelwood to growing stock volume removed as RW |
|---|---|---|---|---|
| Softwood Saw log | 0.99 | 0.182 | 0.891 | 0.019 |
| Softwood Pulpwood | 1.246 | 0.185 | 0.891 | 0.019 |

| | | | | |
|---|---|---|---|---|
| Hardwood Saw log | 0.832 | 0.198 | 0.752 | 0.301 |
| Hardwood Pulpwood | 1.191 | 0.218 | 0.752 | 0.301 |

**Table A4. Calculated Carbon Content of Harvested Wood that Produces Industrial Roundwood**

| | (tons C/ha) |
|---|---|
| Softwood saw log carbon in industrial roundwood | 27.94 |
| Softwood pulpwood carbon in industrial roundwood | 53.84 |
| Hardwood saw log carbon in industrial roundwood | 1.63 |
| Hardwood pulpwood carbon in industrial roundwood | 4.17 |

The average disposition pattern of HWP over time in the Southeast is provided by the USFS methodology. The disposition pattern tracks the flow of softwood and hardwood classes of industrial roundwood through four "pools" over time: carbon in HWP in use, carbon in HWP in landfills, carbon in HWP emitted with energy capture, and carbon in HWP emitted without energy capture. Disposition patterns are provided separately for softwood and hardwood categories and are represented by the fraction of carbon remaining in each pool over time.

Table A5 shows the fraction remaining 100-years after harvest for the Southeast by softwood and hardwood classes. These fractions were multiplied by the corresponding initial carbon contents shows in Table A4 to yield the carbon content remaining 100-yrs post harvest in each pool. The net carbon stock change in HWP is calculated as the total amount of carbon remaining in HWP *in use* or *landfills* after 100-yrs (the other two pools represent carbon emissions).

**Table A5. Fraction of Carbon in HWP Pools 100-yrs Post Harvest (USFS GTR NE-343 Table 6) and Corresponding Calculated Per-area Carbon Stock.**

| | Disposition Factor for 100-yrs | Carbon Stock (tons C/ha) |
|---|---|---|
| **Softwoods-Sawlog** | | |
| in use | 0.104 | 2.91 |
| landfill | 0.232 | 6.48 |
| energy | 0.386 | 10.78 |
| emitted w/o energy | 0.277 | 7.74 |
| **Softwoods-Pulpwood** | | |
| in use | 0.036 | 1.94 |
| landfill | 0.105 | 5.65 |
| energy | 0.463 | 24.93 |
| emitted w/o energy | 0.396 | 21.32 |
| **Hardwoods-Sawlog** | | |
| in use | 0.037 | 0.06 |
| landfill | 0.267 | 0.43 |
| energy | 0.361 | 0.59 |
| emitted w/o energy | 0.335 | 0.54 |
| **Hardwoods-Pulpwood** | | |
| in use | 0.063 | 0.26 |
| landfill | 0.125 | 0.52 |
| energy | 0.385 | 1.61 |

| | | |
|---|---|---|
| emitted w/o energy | 0.427 | 1.78 |
| **Total stored C 100 yrs post harvest (tons C/ha)** | | 18.26 |
| **Total stored C 100 yrs post harvest (tons C/ac)** | | 7.43 |

**Key Assumptions:** Pending

## *Afforestation*

**Data Sources:** Forest carbon stocks from Southern region tables in the US Forest Service Methods for Calculating Forest Ecosystem and Harvested Carbon with Standards Estimates for Forest Types of the US, General Technical Report NE-343 (also published as part of the Department of Energy Voluntary GHG Reporting Program); data on distribution of forest types in SC from USFS Forest Inventory Analysis 2006 inventory data published online. Cost are from a similar analysis for North Carolina.

**Quantification Methods:**

A weighted average annual rate of carbon sequestration for young-aged forests in SC was calculated as 1.1 tons C/ac/yr using data on carbon stocks by age class published by the USFS for the three most dominant forest groups, totaling 80% of private forestland in SC (Table 1). For each forest type group, annual carbon sequestration rates were calculated by subtracting carbon stocks in new stands (0 yrs) from carbon stocks in 15-yr old stands and dividing by 15 yrs. An average rate was calculated, weighted by area of each forest type to take into account variation in carbon sequestration across forest types. A fifteen-year rate was used to reflect the average age of forested stands during the timeframe of analysis. Young stands typically sequester carbon at faster rates than older stands.

**Table 1. Data on carbon stocks, 15-yr annual average sequestration rates, and area by forest type, used to calculate a weighted average annual sequestration rate for forestation.**

| | Carbon Stocks at Age 0 yrs (tons C/ac) | Carbon Stocks at Age 15 yrs (tons C/ac) | Average Annual Sequestration (tC/ac/yr) | Area in 2006 (acres) |
|---|---|---|---|---|
| **Loblolly-shortleaf pine** | | | | |
| Soils | 22.1 | 22.8 | | |
| Biomass* | 1.7 | 18.7 | | |
| Total | 23.8 | 41.5 | 1.180 | 4,750,214 |
| **Oak Hickory** | | | | |
| Soils | 13.7 | 14.1 | | |
| Biomass* | 1.7 | 16.6 | | |
| Total | 15.4 | 30.7 | 1.020 | 2,758,022 |
| **Oak-gum-cypress** | | | | |
| Soils | 48 | 49.3 | | |
| Biomass* | 0.7 | 15.1 | | |
| Total | 48.7 | 64.4 | 1.047 | 1,684,321 |
| | | | | |
| **Area weighted average** | | | | 1.108 |

* Includes live trees, standing dead wood, understory, down dead wood, and litter/debris on the forest floor

Estimated annual acres of land to be afforested were derived from the policy goal, which is to plant a 120,000 acres per year until 2012 (for a total of 1.4 million acres). Approximately 70,000 acres per year are currently planted (G. Sabin, personal communication), thus the goal represents an increase of 50,000 acres planted per year (for a total of 600,000 acres). At this rate, 25% of the total additional acres will be planted by 2012,which is also articulated in the timing of the policy goals.

A forest continues to accumulate carbon each year after it is planted; thus, to calculate the carbon sequestration attributed to this policy option, the weighted average annual carbon sequestration rate was multiplied by the cumulative acres of additional forestland planted each year since 2009. Forested acres (annual and cumulative) and annual total carbon sequestration is shown in Table 2. Reductions are calculated in tons of carbon and converted to standard units of million metric tons of carbon dioxide equivalent (MMtCO2e).

**Table 2. Calculation of annual carbon sequestration from and costs to implement afforestation from 2009 to 2020**.

| | Increase in Acres Planted | Cumulative Increase in Acres Planted | Carbon Sequestration (tons C/yr) | Carbon Sequestration (MMtCO2e/yr) | Cost ($) | Discounted cost ($) |
|---|---|---|---|---|---|---|
| 2009 | 50,000 | 50,000 | 55,378 | 0.20 | $17,000,000 | $17,000,000 |
| 2010 | 50,000 | 100,000 | 110,757 | 0.41 | $17,000,000 | $16,190,476 |
| 2011 | 50,000 | 150,000 | 166,135 | 0.61 | $17,000,000 | $15,419,501 |
| 2012 | 50,000 | 200,000 | 221,513 | 0.81 | $17,000,000 | $14,685,239 |
| 2013 | 50,000 | 250,000 | 276,891 | 1.02 | $17,000,000 | $13,985,942 |
| 2014 | 50,000 | 300,000 | 332,270 | 1.22 | $17,000,000 | $13,319,945 |
| 2015 | 50,000 | 350,000 | 387,648 | 1.42 | $17,000,000 | $12,685,662 |
| 2016 | 50,000 | 400,000 | 443,026 | 1.62 | $17,000,000 | $12,081,583 |
| 2017 | 50,000 | 450,000 | 498,404 | 1.83 | $17,000,000 | $11,506,269 |
| 2018 | 50,000 | 500,000 | 553,783 | 2.03 | $17,000,000 | $10,958,352 |
| 2019 | 50,000 | 550,000 | 609,161 | 2.23 | $17,000,000 | $10,436,525 |
| 2020 | 50,000 | 600,000 | 664,539 | 2.44 | $17,000,000 | $9,939,548 |
| Total | 600,000 | | | 15.84 | | $158,209,042 |

The cost of of $340/acre was estimated based on average costs for tree planting through a typical cost share program, as reported for North Carolina in a similar policy option.[49] In reality, costs will vary depending on specific goals of the tree planting project, species planted, and site conditions. Potential future cost savings from forest products (e.g., merchantable timer or bioenergy feedstocks) is not taken into account. These cost savings would likely not be realized during the timeframe of this analysis.

Annual costs were calculated by multiplying the number of acres planted each year by $340/acre (Table 2). Annual costs were discounted using a 5% rate to convert future dollars to present values. The sum of annual discounted costs from 2009-2020 yields an estimate of the Net

[49] Note MN DNR reports similar costs ranging from $350-$400 per acre to plant trees in existing agricultural fields, including the cost of planting stock, herbicide treatments, equipment rental, labor, and upkeep for the first two years.

Present Value (NPV) of this option, which is on the order of $158 million. The cost effectiveness is calculated by dividing the NPV by the cumulative GHG benefit of 15.84 MMtCO2e over the same time frame, yielding a cost effectiveness of $10 per ton of CO2e saved.

**Key Assumptions:** Pending

### ***Urban Forestry –*** *analysis pending*

## Key Uncertainties

TBD – [as needed and approved by the TWGs]

## Additional Benefits and Costs

TBD – [as needed and approved by the TWGs]

## Feasibility Issues

TBD – [as needed and approved by the TWGs]

## Status of Group Approval

Pending – [until CECAC moves to final agreement at meeting #5 or #6]

## Level of Group Support

TBD – [blank until CECAC meeting #5]

## Barriers to Consensus

TBD – [blank until final vote by the CECAC]

# AFW-7. Conservation and Restoration of Forest and Agriculture Lands for Enhanced Carbon Sequestration

## AFW-7(a). Conservation and Restoration of Agricultural Lands for Enhanced Carbon Sequestration

### Policy Description

In agricultural lands, soil carbon levels can be higher than those converted to developed use. By conserving agricultural lands, GHG emissions can also be reduced indirectly by influencing more efficient development patterns (leading to lower vehicle-miles traveled). Therefore, a suitable policy for carbon sequestration is to incorporate methodologies that reduce the rate at which the existing base of South Carolina agricultural acreages are cleared and converted to developed uses.

### Policy Design

**Goals:** Reduce the rate at which agricultural lands are converted to developed use by 50% by 2020 from current levels.

**Timing:** By 2012, reduce the rate of conversion by 20% from current levels. By 2020, reduce the rate of conversion by 50%.

**Parties Involved:** SC Parks Recreation & Tourism, SC Department of Natural Resources, SC Conservation Bank, SC Department of Agriculture, Santee Cooper, SC Farm Bureau, US Fish & Wildlife Service, US Park Service, Clemson University, NGOs (including but not limited to SC Forestry Association, Ducks Unlimited, The Nature Conservancy, Lowcountry Open Land Trust, Congaree Land Trust, etc.)

**Other:** SC forest and agricultural land conversion 9th in US at 539,700 acres from 1992-97; rate of increased conversion of 30.2% increasing from 13.0% (1982-87) and 14.1% (1987-92).[50] Table XX below displays the change in total agricultural land between 1982 and 1997.[51] This data shows an annual decrease in agricultural lands of 81,000 from 1992-1997, a 10.7% change in total area.

**Table XX: South Carolina Agricultural land use changes 1982-1997**

| Year | Land Cover Change* (1000 Acres) | % Change | Annual Change (1000 acres) |
|---|---|---|---|

[50] London, James B. and Nicole L. Hill. 2000. Land conversion in South Carolina: State makes top 10 list. Jim Self Center on the Future. Clemson University. 6 p.

[51] Natural Resources Conservation Service. SC NRI data provided by the NRCS state office. Provided to B.Strode on December 19, 2007 by R. Morton via e-mail.

| Year | Land Cover Change* (1000 Acres) | % Change | Annual Change (1000 acres) |
|---|---|---|---|
| 1982-1987 | -285.3 | -6.3% | -57.06 |
| 1987-1992 | -347.1 | -8.3% | -69.42 |
| 1992-1997 | -405.3 | -10.7% | -81.06 |
| 1982-1997 | -1037.7 | -27.5% | -69.18 |
| *Agricultural lands include cultivated cropland, noncultivated cropland, and pastureland. | | | |

## Implementation Mechanisms

Policy design considerations include:

(1) Emphasis of grant and partnership opportunities to utilize fee title acquisition to acquire additional State Forest, State Park and Wildlife Management Area lands from willing sellers while incorporating sound forest management plans optimizing forest carbon sequestration on acquired acreage;

(2) Emphasis of opportunities to sequester additional carbon through voluntary private land conservation easements to decrease land conversion and protect agricultural acreage from development;

(3) Utilization of state income tax credit for donations or bargain sales of conservation easements including the potential increase of tax benefits to incentivize agricultural landowners.

Fee Title Acquisitions, Private land Conservation Easements, Landowner Incentives, Infusion of additional funds into the SC Conservation including earmarking some or all of the increase to go to projects that conserve lands where the proposed uses will increase carbon sequestration.

## Related Policies/Programs in Place

A change in Federal tax law is in place for land put into conservation easement through 2007 allowing property owners to offset half of tax liability for 15 years. SC Conservation Bank.

Governor Mark Sanford has proposed a $50 million increase to the South Carolina conservation bank's land fund for 2008.[52]

## Type(s) of GHG Reductions

**CO2:** Conservation of agricultural lands retains the ability of the land to sequester carbon in soil and biomass.

[52] "Sanford wants to add $50 million to land fund." *The State*. Posted on Tuesday, December 11, 2007. Accessed on January 4, 2008 from; http://www.thestate.com/politics/v-print/story/254330.html.

## Estimated GHG Reductions and Net Costs or Cost Savings

TBD – [CCS should provide a worksheet and other reference material as needed for transparency]

**Data Sources: [**TBD by CCS on TWG approval]

**Quantification Methods:**

*GHG Benefit*

Studies are lacking on the changes in below and above-ground carbon stocks when agricultural land is converted to developed uses. For some land use changes, carbon stocks could be higher in the developed use relative to the agricultural use (e.g., parks). In other instances, carbon stocks are likely to be lower (graded and paved surfaces). CCS assumed that the agricultural land would be developed into typical tract-style suburban development. It was further assumed that 50% of the land would be graded and covered with roads, driveways, parking lots, and building pads. The final assumption was that 75% of the soil carbon in the top eight inches of soil for these graded and covered surfaces would be lost and not replaced. CCS assumed no change in the levels of above-ground carbon stocks.

The benefit in each year was determined by:

1. determining the amount of land protected in each year by estimating the annual rate of agricultural land lost (determined from NRI South Carolina data) and assuming that agricultural land protected at an increasing rate up to 2020, where it is assumed loss of agricultural lands is reduced by 50%.
2. multiplying the soil carbon content (0.017 MMtC per 1000 acres[53]) on the protected land by 50% (representing graded and covered areas) and by 75% (fraction of soil carbon lost);
3. converting the soil carbon lost to CO2 by multiplying by 44/12, to factor in the different relative weights of carbon and carbon dioxide.

*Costs*

To estimate program costs in each year, CCS multiplied the estimated agricultural acres protected from development by the conservation cost. The conservation costs were assumed to be $1,461, which is the average easement cost per acre for South Carolina in 2007FY (Financial Assistance Dollars Obligated was $1,189,345 and Number of Acres was 814) from Farm and Ranch Lands Protection Program (FRPP)[54]. It is assume that subsidies are available through the

[53] Franzluebbers, A.J., B. Grose, L.L. Hendrix, P.K. Wilkerson, B.G. Brock, "Surface-Soil Properties in Response to Silage Intensity under No-Tillage Management in the Piedmont of North Carolina", presented at the 25th Southern Conservation Tillage Conference for Sustainable Agriculture, Auburn, AL, June 24-26, 2002.

[54] See http://www.nrcs.usda.gov/programs/frpp/2007_Easements/2007FRPPEasements.html

Farm and Ranch Land Protection Program (FRPP)[55] for a 50% cost share. Subsidies received through the FRPP are excluded from the program costs. The resulting cost effectiveness is $X/Mt. This estimate only accounts for the direct reductions associated with soil carbon losses estimated above and does not include potentially much larger indirect benefits associated with reductions in vehicle miles traveled.

**Key Assumptions: [**TBD, as needed on TWG approval]

## Key Uncertainties

Hurricanes, societal costs, tradeoffs, leakage

## Additional Benefits and Costs

TBD – [as needed and approved by the TWGs]

## Feasibility Issues

TBD – [as needed and approved by the TWGs]

## Status of Group Approval

Pending – [until CECAC moves to final agreement at meeting #5 or #6]

## Level of Group Support

TBD – [blank until CECAC meeting #5]

## Barriers to Consensus

TBD – [blank until final vote by the CECAC]

[55] The FRPP provides matching funds (up to 50%) to keep productive farm and ranchland in agricultural uses. Working through existing programs, USDA partners with State, tribal, or local governments and non-governmental organizations to acquire conservation easements or other interests in land from landowners.

## AFW-7(b). Conservation and Restoration of Forestlands for Enhanced Carbon Sequestration

### Policy Description

Forests can play a substantial role in climate change by sequestering (or storing) carbon (by absorbing CO2) as trees grow and releasing it as they decay. Trees are powerful, relatively low cost concentrators of carbon. Young forests sequester carbon at a high rate, roughly proportional to forest growth in biomass. Old growth forests have a large balance of carbon stored over time in wood and soil.[56] Forests set aside to promote old growth result in long term carbon storage balance due to a negligible rate of additional carbon sequestration because of natural loss and decay at about the same rate as they are growing.[57] Land use changes resulting in forest conversion to other uses are generally believed to be a secondary source of net carbon release.[58] Much of the carbon stored in forest biomass and soils can be released as a result of such land use conversion in addition to the loss in future carbon sequestration. Therefore a suitable policy for carbon sequestration is to incorporate methodologies that promote long-term maintenance of the existing base of South Carolina (SC) forest acreages and support public policies that encourage and enhance carbon sequestration on those lands. Another appropriate policy to sequester carbon is to encourage the manufacture and use of durable wood products sequestering carbon over the life of the wooden product.

Conversion of cropland acreage to forest acreage can produce GHG benefits by adding above and below ground biomass (sequestering carbon) to the converted area. Also, the converted area is likely to sequester more carbon annually as forested area than cropland. This option also covers programs aimed at protecting forested areas that were previously converted (e.g., returned to active cultivation).

### Policy Design

**Goals:** Increase the acreage of forestlands by 5% from current levels.

*The only clear way to attribute ghg reductions to conservation/protection of forest is to demonstrate that in the absence of conservation, the forests would be "lost", i.e. converted to development (i.e., “avoided deforestation”). This concept may be implied within the goal above (however net gains in forest area can occur even with increases in forest conversion if afforestation rates are high). Is it possible to reframe this goal in terms of reducing the rate of forest acres converted to development statewide compared to what's projected for the future?*

**Timing:** Achieve no net annual loss of forestlands by 2012. Achieve full goal by 2020.

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[56] R.A. Sedjo. 2001. Forest carbon sequestration: Some issues for forest investments. Discussion Paper 01-34. 26 pp. Resources for the Future. Washington, DC. Available at: http://www.rff.org/Documents/RFF-DP-01-34.pdf

[57] B. Sohngen, R. Mendelsohn, and R. Sedjo. 1998. The Effectiveness of forest carbon sequestration strategies with system-wide adjustments. Available at: http://www-agecon.ag.ohio-state.edu/peole/sohngen.1/forests/effectc.pdf

[58] R.N. Stavins and K.R. Richards. 2005.The cost of US forest-based carbon sequestration. Pew Center for Global Climate Change. Available at: http://www.pewclimate.org/docUploads/sequest_Final.pdf

*According to FIA data, there was a net increase in forest cover in SC from 2001 to 2006 on the order of 1.5% (or 0.3%/yr), suggesting that under baseline conditions there is already no net loss of forests in SC. The FIA data are inconsistent with the table below (what's the source for the table?).*

**Parties Involved:** SC Forestry Commission, SC Forestry Association, SC Parks Recreation & Tourism, SC Department of Natural Resources, SC Conservation Bank, SC Department of Agriculture, Santee Cooper, SC Farm Bureau, US Fish & Wildlife Service, US Forest Service, US Park Service, Clemson University, NGOs (including but not limited to SC Forestry Association, Ducks Unlimited, The Nature Conservancy, Lowcountry Open Land Trust, Congaree Land Trust, etc.)

**Other:** SC forestlands declined in area by 142,000 acres to 12.3 million acres from 1993 to 2000. Table XX below expresses land use changes involving forestlands over this period of time.[59]

**Table XX: Land Use Changes Involving South Carolina Forestlands; 1993-2000**

| *Land Use Change* | *Number of Acres* |
|---|---|
| Forestland aleared for agriculture | 205,000 |
| Forestland diverted to urban and other uses | 392,000 |
| Forestland converted to lakes, ponds, or other impoundments | 51,000 |
| Land added to the timber base through reforestation and natural regeneration | 506,000 |
| Total Change in Forestlands | -142,000 |

The TWG reports that the most recent USFS survey shows an increase in SC forest acreage from 12.4 million acres to 12.7 million acres, although this survey data has not yet been acquired by CCS.

## Implementation Mechanisms

Policy design considerations include:

(1) Placing land in protected status through the emphasis of grant and partnership opportunities to utilize fee title acquisition to acquire additional State Forest, State Park and Wildlife Management Area lands from willing sellers while incorporating sound forest management plans optimizing forest carbon sequestration on acquired acreage;

[59] Conner, R.C., and R.M. Sheffield. 2001. "South Carolina's Forest Resources – 2000 Update." United States Department of Agriculture: Forest Service – Southern Research Station. Resources Bulletin SRS-65. Accessed on January 2, 2008 from: http://www.state.sc.us/forest/fia2000.pdf.

(2) Long-term protection of privately owned lands by seeking opportunities to sequester additional carbon through voluntary private land conservation easements to decrease land conversion and protect forest and agricultural acreage from development;

(3) Facilitate profitable management of existing forest and agricultural land uses by strengthening landowner technical assistance, cost-sharing such as the Forest Renewal Program, and education programs. Consider incentives to keep land in forest and agricultural use through favorable tax treatment and protection from local regulation that impact land management activities. Encourage growth management efforts to recognize the value of maintaining forest and farm lands and discourage sprawl while respecting landowner rights.

(4) Provide additional funding for reforestation programs to convert idle agricultural acreage to forest land and more rapid reforestation of cut-over forest acreage, and

(5) Explore carbon markets as incentives for enhancing carbon sequestration on forest and farm lands. Consider opportunities for a state carbon registry and trading of carbon offsets.

## Related Policies/Programs in Place

A change in Federal tax law is in place for land put into conservation easement through 2007 allowing property owners to offset half of tax liability for 15 years. SC Conservation Bank.

Governor Mark Sanford has proposed a $50 million increase to the South Carolina conservation bank's land fund for 2008.[60]

## Type(s) of GHG Reductions

**CO2:** Conservation of agricultural lands retains the ability of the land to sequester carbon in soil and biomass.

## Estimated GHG Reductions and Net Costs or Cost Savings

TBD – [CCS should provide a worksheet and other reference material as needed for transparency]

**Data Sources: [**TBD by CCS on TWG approval]

**Quantification Methods:** [e.g. Full life-cycle analysis with supply/demand equilibrium adjustments on TWG approval]

**Key Assumptions: [**TBD, as needed on TWG approval]

[60] "Sanford wants to add $50 million to land fund." *The State*. Posted on Tuesday, December 11, 2007. Accessed on January 4, 2008 from; http://www.thestate.com/politics/v-print/story/254330.html.

## Key Uncertainties

Hurricanes, societal costs, tradeoffs, leakage

## Additional Benefits and Costs

TBD – [as needed and approved by the TWGs]

## Feasibility Issues

TBD – [as needed and approved by the TWGs]

## Status of Group Approval

Pending – [until CECAC moves to final agreement at meeting #5 or #6]

## Level of Group Support

TBD – [blank until CECAC meeting #5]

## Barriers to Consensus

TBD – [blank until final vote by the CECAC]

# AFW-8. Advanced Recycling and Composting

## Policy Description

Increase the use of recycling and composting as waste diversion methods in order to limit greenhouse gas emissions associated with landfill methane generation and to increase production efficiencies of raw materials and new products. In order to achieve the goals set forth below, it will be necessary to: increase awareness of the value of recycling, develop consistent recycling programs across counties, promote "best practices" comparisons across counties and between other states, increase recycling programs, create new recycling programs, provide incentives for the recycling of construction & demolition (C&D) waste[61], develop markets for recycled materials and compost, and increase average participation/recovery rates for all existing recycling and composting programs.

## Policy Design

**Goals:** Increase recycling of municipal solid waste (MSW), as defined by the EPA, in the state to a total of 35% by 2020. Increase composting to 10% by 2020. [Note to TWG, CECAC would like to see a range of benefits/costs estimated for the current goal, as well as a 50% recycling goal]

**Timing:** Achieve an MSW recycling rate of 30% and a composting rate of 5.25% by 2012.

**Parties Involved:** Municipal and county government, private solid waste and recycling management companies, commercial, industrial and institutional generators, and SC DHEC.

**Other:** Out of an estimated 4.97 million tons of MSW generated in the state of South Carolina in fiscal year 2006, 3.24 million tons were landfilled and 0.22 million tons were incinerated. The FY2006 diversion rate in South Carolina was 30.4%, or 1.5 million tons (diversion includes recycling and composting). Based on the 30.4% diversion rate, the current disposal rate is 4.4 lb/person/year. The FY2006 recycling rate in South Carolina was 24.8% and the composting rate was 5.54%.[62]

## Implementation Mechanisms

- Review current exclusions from the landfill to determine if there are possible additions – if so, recycling programs will need to be considered
- Establish C&D recycling targets and create a draft program
- Support increased business recycling efforts, e.g. SC Smart Business Recycling Program
- Establish ewaste recycling targets and a draft program – several states can be used as models (Maryland, California, Washington and Maine)

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[61] Note: SC does not include construction and demolition debris within the calculation of recycling rates for MSW recycling. *If the C&D waste is emplaced at specified C&D landfills?*

[62] SC DHEC. "South Carolina Solid Waste Management Annual Report; Fiscal Year 2006." Accessed on November 20, 2007 from: http://www.scdhec.net/eqc/lwm/recycle/forms/swmr_06.pdf

- Investigate a separate recycling program for the statewide hospitality industry (Note: NC will soon ban from landfills all alcohol beverage containers collected from restaurants)
- Evaluate and make recommendations relative to SC pilot programs to increase household/municipalities recycling rates – e.g. Charleston County
- Investigate national pilot programs to increase household/municipalities recycling rates – e.g. RecycleBank programs in Philadelphia and Wilmington, DL
- Investigate local and state level programs to increase household and commercial composting opportunities – e.g. Cobb County, GA has a well recognized commercial composting program, a NJ university installed a rotary digester/composting system to handle food waste
- Continue to evaluate, revise and fund education efforts aimed at consumers and businesses to increase awareness of the value of recycling and participation levels in recycling programs – Create a mandate to participate
- Continue efforts to improve reporting at the county level to make certain there is consistency across the counties
- Implement a "best practices" approach across all SC counties to improve overall recycling and composting levels
- Implement a "best practices" approach nationally to uncover innovative and effective actions to improve overall recycling and composting levelsIncrease the emphasis on alignment among state, county and local solid waste plans

## Related Policies/Programs in Place

The S.C. Solid Waste Policy and Management Act of 1991 (Act) established the state's approach to solid waste management. The Act sets statewide recycling and disposal goals. DHEC is required to publish a comprehensive annual report – based in part on the required information that counties provide – on solid waste management in the state for the previous fiscal year (FY). The annual report is an excellent source of current and historical information and recommendations relative to solid waste management in SC.

The Recycled Market Development Advisory Council, SC Department of Commerce, is a source of recent actions for Advanced Recycling. Another program to promote business recycling is the "Smart Business Program". DHEC is also issuing a new rule covering composting. This rule is due to be out in late July and covers wood waste only. Dept. of Commerce is currently considering incentives for recycling, especially business recycling. DOC is also considering waste-to-energy options and compost options. The South Carolina Recycling Market Development Advisory Council managed by the Department of Commerce maintains an ongoing program to explore market opportunities for recycled materials in SC. The RMDAC has recently produced a study of the "Economic Impact of the Recycling Industry in South Carolina." The RMDAC meets bi-monthly to "raise awareness of the current state of recycling in South Carolina through various marketing strategies." The Annual Report of the RMDAC is a resource for an overview of the current status of the recycling industry in SC. [Note to TWG, the CECAC would like to see information on current levels of recycling by county; should be available through DHEC] (This information is in the DHEC Annual Report at a high level of detail and should be available in greater detail as part of the Re-TRAC web based data collection system). [NOTE]: CECAC would like to see information on current levels of recycling by county. CCS has obtained this information and will be summarizing it prior to CECAC meeting.

## Type(s) of GHG Reductions

**$CH_4$, $CO_2$:** Methane reductions from avoided methane emissions from waste placed into landfills; GHG reductions from lower energy consumption associated with a reduction of wastes generated (e.g. energy used to create products or packaging); GHG reductions from lower energy consumption associated with utilizing recycled materials for production versus raw (virgin) materials.

## Estimated GHG Reductions and Net Costs or Cost Savings

TBD – [CCS should provide a worksheet and other reference material as needed for transparency]

**Data Sources:** Data on current waste generation and recycling rates were taken from the Fiscal Year 2006 South Carolina Solid Waste Management Annual Report.[63] DHEC reports the composting of yard trimmings and food wastes as a part of the recycling stream in the FY2006 SWM report. The breakdown of the waste disposed in Maryland by type was derived from US-level data provided in the EPA 2005 Waste Characteristics Report.[64] GHG emission reductions were modeled using the U.S. Environmental Protection Agency's (EPA's) Waste Reduction Model (WARM).[65] Table 9-1 displays the historical data contained within the Annual Waste Management reports from fiscal years 2002-2006.[66] NOTE: Specific recycling and composting data is not reported for years 2002-2005 in the tables below, as CCS is awaiting delivery of reports from 2002 and 2003 from DHEC.

**Table 9-1: Historical Disposal, Diversion, and Generation Data for South Carolina, 2002-2006.**

| Item | 2002 | 2003 | 2004* | 2005 | 2006 |
|---|---|---|---|---|---|
| Landfill Disposal | 2,921,378 | 3,059,022 | 3,111,627 | 3,219,645 | 3,239,763 |
| Waste to Energy (Incinerator Disposal) | 208,626 | 201,146 | 227,802 | 227,031 | 224,506 |

[63] *South Carolina Solid Waste Management Annual Report – FY2006.* SC DHEC: Division of Mining and Solid Waste Management. Accessed on December 13, 2007 from http://www.scdhec.gov/environment/lwm/recycle/pubs/swmr_06.pdf.

[64] *Municipal Solid Waste in the United States, 2005 Facts and Figures*, US EPA, Office of Solid Waste, EPA530-R-06-011, October 2006. Accessed on December 30, 2007 from: http://www.epa.gov/garbage/pubs/mswchar05.pdf.

[65] Version 8, May 2006. From http://www.epa.gov/climatechange//wycd/waste/calculators/WARM_home.html. EPA created WARM to help solid waste planners and organizations track and voluntarily report GHG emission reductions from several different waste management practices. WARM is available both as a Web-based calculator and as a Microsoft Excel spreadsheet. WARM calculates and totals GHG emissions of baseline and alternative waste management practices—source reduction, recycling, combustion, composting, and landfilling. The model calculates emissions in tCe, $tCO_2e$, and energy units (million Btu) across a wide range of material types commonly found in MSW. For an explanation of the methodology, see the EPA report *Solid Waste Management and Greenhouse Gases: A Life Cycle Assessment of Emissions and Sinks*, EPA530-R-02-006, at http://epa.gov/climatechange/wycd/waste/SWMGHGreport.html

[66] Annual reports from FY2004-2006 are available online at: http://www.scdhec.gov/environment/lwm/recycle/resource_center.htm. Reports from FY 2002-2003 were obtained via mail from SC DHEC and are publicly available upon request.

| Item | 2002 | 2003 | 2004* | 2005 | 2006 |
|---|---|---|---|---|---|
| Diversion | 1,262,331 | 1,318,119 | 965,916 | 1,222,098 | 1,510,409 |
| Diversion % | 28.7% | 28.8% | 22.4% | 26.2% | 30.4% |
| Recycling | | | | | 1,234,596 |
| Reycling % | | | | | 24.8% |
| Composting | | | | | 275,813 |
| Composting % | | | | | 5.54% |
| *Total Generation* | **4,392,335** | **4,578,287** | **4,305,345** | **4,668,774** | **4,974,678** |
| *% Change* | | 4.23% | -5.96% | 8.44% | 6.55% |
| *Average Annual Change* | | | | | 3.31% |
| *Per conversation with Richard Chesley of SC DHEC, data collection practices changed at DHEC, causing a shift in the waste management profile. | | | | | |

**Quantification Methods:**

*GHG Benefits*

The GHG benefits resulting from increased recycling and composting in South Carolina are quantified by:

1. Establishing business-as-usual (BAU) projections for landfill disposal, incineration, recycling, and composting;
2. Using the goals set forth by the TWG to project the policy scenario for waste management;
3. Using recycling data from the SC SWM Annual Report and national-level generation and disposal data from the EPA 2005 Waste Characteristics study, disaggregate the SC recycling, composting and disposal data; and
4. Inserting the resulting waste characterization for the baseline and policy scenarios into the WARM model to determine the incremental GHG benefit resulting from the goals set forth in this policy option.

As reported, the baseline recycling and composting rates for MSW in South Carolina are 24.8% and 5.54%, respectively. Based on the change in MSW generation over the last 5 years, it is assumed that the BAU average annual increase in MSW generation is 3.31%. Additionally, it is assumed that 4.51% of MSW generated is managed at waste-to-energy incineration facilities. Population projections are consistent with those used in the development of the South Carolina Inventory and Forecast (I&F). These assumptions are used to develop the BAU waste management scenario depicted in Table 9-2.

**Table 9-2: Business-as-Usual Waste Management Projection for South Carolina**

| Item | 2006 | 2010 | 2012 | 2015 | 2020 |
|---|---|---|---|---|---|

| Item | 2006 | 2010 | 2012 | 2015 | 2020 |
|---|---|---|---|---|---|
| MSW Generation (3.31%/yr growth 2002-2005) | 4,974,678 | 5,666,755 | 6,048,103 | 6,668,778 | 7,847,983 |
| SC Population (from I&F) | 4,274,818 | 4,458,930 | 4,540,859 | 4,687,920 | 4,916,870 |
| MSW Generation per capita (tons/person) | 1.16 | 1.27 | 1.33 | 1.42 | 1.60 |
| MSW Recycled (24.8% of generation, not including organics) | 1,234,596 | 1,406,353 | 1,500,994 | 1,655,031 | 1,947,681 |
| MSW Disposed in landfills | 3,239,763 | 3,690,479 | 3,938,832 | 4,343,047 | 5,111,005 |
| Waste to Energy (incineration, 4.51% of generation) | 224,506 | 255,739 | 272,949 | 300,960 | 354,178 |
| Organic Composting (5.54% of generation) | 275,813 | 314,184 | 335,327 | 369,740 | 435,119 |

The policy goals set forth by the TWG are applied to the baseline recycling and composting tonnages to project the future waste management under the policy scenario. The tons disposed through other management techniques (landfill and incineration) are filled in by assuming that the share of waste disposed managed by each remains constant. Table 9-3 shows the projected management of waste generated in SC under the policy scenario and Table 9-4 shows the incremental waste diversion, or the difference between the policy and BAU scenarios.

**Table 9-3: Waste Management Projection for South Carolina – Including Policy Goals**

| Item | 2006 | 2010 | 2012 | 2015 | 2020 |
|---|---|---|---|---|---|
| MSW Generation | 4,974,678 | 5,666,755 | 6,048,103 | 6,668,778 | 7,847,983 |
| MSW Recycled | 1,234,596 | 1,504,244 | 1,814,431 | 2,125,673 | 2,746,794 |
| MSW Disposed in landfills (after incremental recycling & composting) | 3,239,763 | 3,590,882 | 3,619,935 | 3,780,939 | 4,036,662 |
| Waste to Energy (incineration, 7.96% of waste not recycled or composted) | 224,506 | 248,838 | 250,851 | 262,008 | 279,729 |
| Organic Composting | 275,813 | 322,791 | 362,886 | 500,158 | 784,798 |

**Table 9-4: Incremental Diversion Under Policy Goals**

| Item | 2006 | 2010 | 2012 | 2015 | 2020 |
|---|---|---|---|---|---|
| Recycling | - | 97,891 | 313,436 | 470,642 | 799,112 |
| Landfill Disposal | - | -99,597 | -318,897 | -562,108 | -1,074,343 |
| Waste to Energy (incineration) | - | -6,902 | -22,099 | -38,952 | -74,449 |

| Item | 2006 | 2010 | 2012 | 2015 | 2020 |
|---|---|---|---|---|---|
| Organic Composting | - | 8,607 | 27,559 | 130,419 | 349,680 |

The national baseline composition of waste generated is used to develop the breakdown of waste generation for South Carolina by waste type.[67] The waste types used for this analysis correspond to the disaggregated recycling information provided in the SC SWM annual repots and the inputs available for the WARM model. Table 9-5 shows the waste generation characteristics of broad waste categories and Table 9-6 shows the mix of generation by specific waste type within some of these categories. Again, the information in these tables is national data that are assumed to adequately represent the South Carolina waste stream.

**Table 9-5: Waste Generation Characteristics, by Category**

| Category | Baseline Genearation Composition (BAU) |
|---|---|
| Paper | 34.2% |
| Organics | 25.0% |
| Mixed Plastic | 11.8% |
| Metals | 7.6% |
| Glass | 5.5% |
| Other | 15.9% |

**Table 9-6: Waste Generation Characteristics, by Waste Type**

| Waste Type | Baseline Generation Composition (BAU) |
|---|---|
| *% of Discarded Paper* | |
| Corrugated Cardboard | 42.8% |
| Magazines/Third Class Mail | 9.9% |
| Newspaper | 14.4% |
| Office Paper | 7.8% |
| Phonebooks | 0.8% |
| Mixed Paper, Broad | 24.3% |
| % of Discarded Organics | |
| Food Waste | 47.7% |
| Yard Trimmings | 52.3% |
| *% of Discarded Plastics* | |
| HDPE | 25.9% |

[67] *Municipal Solid Waste in the United States, 2005 Facts and Figures*, US EPA, Office of Solid Waste, EPA530-R-06-011, October 2006. Accessed on December 30, 2007 from: http://www.epa.gov/garbage/pubs/mswchar05.pdf.

| Waste Type | Baseline Generation Composition (BAU) |
|---|---|
| LDPE | 28.1% |
| PET | 11.8% |
| Other (assumed mixed plastics) | 34.2% |
| *% of Discarded Metals* | |
| Aluminum Cans | 17.1% |
| Steel | 12.7% |
| Mixed Metals | 70.2% |

The mix of waste generation shown in Tables 9-5 and 9-6 are applied to the total waste generation in SC. Next, the shares of waste recycled and composted (Table 9-7) within each of these categories are multiplied by the total amount of waste recycled (or composted for "Food Waste" and "Yard Trimmings") to yield the amount of waste recycled or composted by waste type.[68]

**Table 9-7: Recycled and Composted Waste Characteristics, by Category and Waste Type**

| | ***Tons Collected*** | | | |
|---|---|---|---|---|
| ***Total Disposed*** | ***4,974,678*** | ***% of Total*** | | |
| *Landfill* | 3,239,763 | 65.13% | | |
| *Incinerator* | 224,506 | 4.51% | | |
| ***Total Recycled*** | ***1,510,409*** | ***30.36%*** | | |
| ***Total Recycled (excluding organics)*** | ***1,234,596*** | ***24.82%*** | ***% of Recycled*** | |
| ***Paper*** | ***822,026*** | ***16.52%*** | ***66.58%*** | ***% of Paper**** |
| Corrugated Cardboard | 453,956 | 9.13% | 36.77% | 55.22% |
| Magazines/Third Class Mail | 11,549 | 0.23% | 0.94% | 1.40% |
| Newspaper | 131,431 | 2.64% | 10.65% | 15.99% |
| Office Paper | 58,917 | 1.18% | 4.77% | 7.17% |
| Phone Books | 936 | 0.02% | 0.08% | 0.11% |
| Mixed/Other | 165,238 | 3.32% | 13.38% | 20.10% |
| ***Organics*** | ***275,813*** | ***5.54%*** | ***NA*** | ***% of Organics*** |
| Food Waste | 24 | 0.00% | 0.00% | 0.01% |
| Yard Trimmings | 275,789 | 5.54% | 22.34% | 99.99% |
| ***Plastic*** | ***20,380*** | ***0.41%*** | ***1.65%*** | ***% of Plastic*** |
| HDPE | 6,887 | 0.14% | 0.56% | 33.79% |
| LDPE | 1,668 | 0.03% | 0.14% | 8.18% |

[68] *South Carolina Solid Waste Management Annual Report – FY2006.* SC DHEC: Division of Mining and Solid Waste Management. Accessed on December 13, 2007 from http://www.scdhec.gov/environment/lwm/recycle/pubs/swmr_06.pdf.

| | | | | |
|---|---|---|---|---|
| PET | 2,504 | 0.05% | 0.20% | 12.29% |
| Mixed/Other | 9,321 | 0.19% | 0.75% | 45.74% |
| ***Metal*** | ***201,241*** | ***4.05%*** | ***16.30%*** | ***% of Metal**** |
| Aluminum | 34,791 | 0.70% | 2.82% | 17.29% |
| Steel | 2,817 | 0.06% | 0.23% | 1.40% |
| Mixed/Other | 163,633 | 3.29% | 13.25% | 81.31% |
| ***Glass*** | ***11,090*** | ***0.22%*** | ***0.90%*** | |
| ***Other (Mixed Recyclables)*** | ***179,859*** | ***3.62%*** | ***14.57%*** | |
| *FY2005 percentages used due to unusual results for FY2006 in these categories. Tons collected calculated from these percentages. | | | | |

Once the tonnages of waste generated, recycled, and composted are established. Subtracting the waste generated for each waste type by the diversion for the corresponding waste type disaggregates the waste landfilled and incinerated. The shares of waste disposed that are landfilled and incinerated in FY2006 are preserved throughout the policy period for both the BAU and Policy scenarios. Therefore, the waste disposed for each waste type is multiplied by 0.935 to yield the tons of waste landfilled and 0.065 for the tons of waste incinerated.[69]

The results of this process are entered into the EPA WARM model. The WARM inputs for 2020 are displayed in Tables 9-8 and 9-9.

**Table 9-8: 2020 Baseline WARM Inputs**

| Material | Tons Generated | Tons Recycled | Tons Landfilled | Tons Combusted | Tons Composted |
|---|---|---|---|---|---|
| Aluminum Cans | 101,992 | 54,886 | 44,053 | 3,053 | NA |
| Steel Cans | 75,749 | 4,443 | 66,684 | 4,621 | NA |
| Copper Wire | | | | | NA |
| Glass | 431,639 | 17,495 | 387,305 | 26,839 | NA |
| HDPE | 239,850 | 10,865 | 214,146 | 14,840 | NA |
| LDPE | 260,223 | 2,631 | 240,898 | 16,694 | NA |
| PET | 109,275 | 3,950 | 98,499 | 6,826 | NA |
| Corrugated Cardboard | 1,148,756 | 716,154 | 404,567 | 28,035 | NA |
| Magazines/Third-class Mail | 265,717 | 18,219 | 231,459 | 16,039 | NA |
| Newspaper | 386,497 | 207,343 | 167,544 | 11,610 | NA |
| Office Paper | 209,353 | 92,947 | 108,862 | 7,544 | NA |
| Phonebooks | 21,472 | 1,477 | 18,699 | 1,296 | NA |
| Textbooks | | | | | NA |
| Dimensional Lumber | | | | | NA |
| Medium-density Fiberboard | | | | | NA |
| Food Scraps | 935,872 | NA | 875,186 | 60,648 | 38 |

[69] (3,239,763 tons landfilled) / (3,239,763 tons landfilled + 224,506 tons incinerated) = 0.935

| Material | Tons Generated | Tons Recycled | Tons Landfilled | Tons Combusted | Tons Composted |
|---|---|---|---|---|---|
| Yard Trimmings | 1,026,124 | NA | 552,740 | 38,303 | 435,081 |
| Grass | | NA | | | |
| Leaves | | NA | | | |
| Branches | | NA | | | |
| Mixed Paper (general) | 652,214 | 260,677 | 366,164 | 25,374 | NA |
| Mixed Paper (primarily residential) | | | | | NA |
| Mixed Paper (primarily from offices) | | | | | NA |
| Mixed Metals | 418,706 | 258,146 | 150,155 | 10,405 | NA |
| Mixed Plastics | 316,713 | 14,705 | 282,436 | 19,572 | NA |
| Mixed Recyclables | 1,247,829 | 283,743 | 901,607 | 62,479 | NA |
| Mixed Organics | | NA | | | |
| Mixed MSW | | NA | | | NA |
| Carpet | | | | | NA |
| Personal Computers | | | | | NA |
| Clay Bricks | | NA | | NA | NA |
| Concrete[1] | | | | NA | NA |
| Fly Ash[2] | | | | NA | NA |
| Tires[3] | | | | | NA |

**Table 9-8: 2020 Policy WARM Inputs**

| Material | Baseline Generation | Tons Recycled | Tons Landfilled | Tons Combusted | Tons Composted |
|---|---|---|---|---|---|
| Aluminum Cans | 101,992 | 77,405 | 22,994 | 1,593 | NA |
| Steel Cans | 75,749 | 6,266 | 64,980 | 4,503 | NA |
| Copper Wire | - | | | | NA |
| Glass | 431,639 | 24,674 | 380,592 | 26,374 | NA |
| HDPE | 239,850 | 15,323 | 209,977 | 14,551 | NA |
| LDPE | 260,223 | 3,711 | 239,889 | 16,624 | NA |
| PET | 109,275 | 5,571 | 96,984 | 6,721 | NA |
| Corrugated Cardboard | 1,148,756 | 1,009,984 | 129,779 | 8,993 | NA |
| Magazines/Third-class Mail | 265,717 | 25,694 | 224,468 | 15,555 | NA |
| Newspaper | 386,497 | 292,414 | 87,986 | 6,097 | NA |
| Office Paper | 209,353 | 131,082 | 73,199 | 5,072 | NA |
| Phonebooks | 21,472 | 2,083 | 18,133 | 1,257 | NA |
| Textbooks | - | | | | NA |
| Dimensional Lumber | - | | | | NA |
| Medium-density Fiberboard | - | | | | NA |
| Food Scraps | 935,872 | NA | 875,158 | 60,646 | 68 |
| Yard Trimmings | 1,026,124 | NA | 225,750 | 15,644 | 784,730 |

| Material | Baseline Generation | Tons Recycled | Tons Landfilled | Tons Combusted | Tons Composted |
|---|---|---|---|---|---|
| Grass | - | NA | | | |
| Leaves | - | NA | | | |
| Branches | - | NA | | | |
| Mixed Paper, Broad | 652,214 | 367,629 | 266,142 | 18,443 | NA |
| Mixed Paper, Resid. | - | | | | NA |
| Mixed Paper, Office | - | | | | NA |
| Mixed Metals | 418,706 | 364,060 | 51,104 | 3,541 | NA |
| Mixed Plastics | 316,713 | 20,738 | 276,794 | 19,181 | NA |
| Mixed Recyclables | 1,247,829 | 400,160 | 792,735 | 54,934 | NA |
| Mixed Organics | - | NA | | | |
| Mixed MSW | - | NA | | | NA |
| Carpet | - | | | | NA |
| Personal Computers | - | | | | NA |
| Clay Bricks | - | NA | | NA | NA |
| Concrete[1] | - | | | NA | NA |
| Fly Ash[2] | - | | | NA | NA |
| Tires[3] | - | | | | NA |

The results of the WARM analysis predict a GHG benefit of 1.18 $MMtCO_2e$ in 2012 and 3.01 $MMtCO_2e$ in 2020. Assuming a the program implementation begins in 2010 and a linear increase in emissions reductions between target years, the cumulative GHG benefit is estimated to be 20.1 $MMtCO_2e$ through 2020 (see Table 9-9).

**Table 9-9: Overall Policy Results – GHG Benefits**

| Year | Avoided Emissions (MMtCO2e) | Incremental Waste Diversion (tons) | Incremental Recycling (tons) | Avoided Landfill Emplacement (tons) | Avoided WTE Emplacement (tons) |
|---|---|---|---|---|---|
| 2009 | - | - | - | - | - |
| 2010 | 0.39 | 106,498 | 97,891 | -99,597 | -6,902 |
| 2011 | 0.79 | 220,047 | 202,263 | -205,786 | -14,260 |
| 2012 | 1.18 | 340,995 | 313,436 | -318,897 | -22,099 |
| 2013 | 1.41 | 422,576 | 362,863 | -395,190 | -27,386 |
| 2014 | 1.64 | 509,183 | 415,218 | -476,185 | -32,998 |
| 2015 | 1.87 | 601,061 | 470,642 | -562,108 | -38,952 |
| 2016 | 2.10 | 698,463 | 529,280 | -653,198 | -45,265 |
| 2017 | 2.33 | 801,654 | 591,283 | -749,702 | -51,952 |
| 2018 | 2.55 | 910,912 | 656,812 | -851,879 | -59,033 |
| 2019 | 2.78 | 1,026,524 | 726,031 | -959,999 | -66,525 |
| 2020 | 3.01 | 1,148,792 | 799,112 | -1,074,343 | -74,449 |
| **Totals** | 20.1 | 6,786,705 | 5,164,832 | -6,346,884 | -439,820 |

*Cost Effectiveness*

Methodology for estimating the cost effectiveness of AFW-8 requires the following SC-specific information:

- Average landfill tipping fee
- Average recycling facility tipping fee (paid to either the hauler or recycler)
- Average compost facility tipping fee
- Average value of compost
- Capital and O&M cost for recycling facilities
- Capital and O&M cost for composting facilities
- Collection cost for source-separated compost and recycling programs
- Education and/or enforcement program costs.

**Key Assumptions: [**TBD, as needed on TWG approval]

## Key Uncertainties

TBD – [as needed and approved by the TWGs]

## Additional Benefits and Costs

TBD – [as needed and approved by the TWGs]

## Feasibility Issues

TBD – [as needed and approved by the TWGs]

## Status of Group Approval

Pending – [until CECAC moves to final agreement at meeting #5 or #6]

## Level of Group Support

TBD – [blank until CECAC meeting #5]

## Barriers to Consensus

TBD – [blank until final vote by the CECAC]Sample Draft Policy Option Template]

# AFW-9. Organics Management for Energy Recovery

## Policy Description

Promote the use of anaerobic digesters and energy recapture for organic waste materials (e.g. food processing waste, yard waste, other organics; Note the linkage to AFW-2, whereby some organics from this waste stream could be co-managed with livestock wastes, and to the AFW-8 composting goals). Also, for waste that is landfilled, promote the use of landfill gas to energy (LFGTE) projects. These projects will help prevent the emission of methane while producing clean energy. Anaerobic digesters make a two-fold contribution to climate protection: the usual unchecked discharge of methane into the atmosphere is prevented; and the burning of fossil fuels is replaced with renewable energy (biogas). Use the clean, renewable energy created at landfills by anaerobic digesters to make electric power, space/process heat, and liquefied/compressed natural gas. Note that this policy is not promoting waste combustion to energy projects.

## Policy Design

**Goals:** Increase the number of uncontrolled municipal solid waste landfills recovering methane as an energy source, such that 50% of the landfill gas being generated at uncontrolled landfill sites is controlled by 2020. This can be done through development of additional landfill gas to LFGTE and anaerobic digester projects.

**Timing:** By 2012, implement LFGTE/digester projects at currently uncontrolled landfills or other sites, such that 20% of methane released at these sites is recovered as an energy source; by 2020, achieve full implementation of the policy.

**Parties Involved:** Municipal and county governments, private solid waste management companies, local economic development agencies, SC DHEC, SC Department of Commerce, SC Energy Office, non-government organizations, and public interest groups.

**Other:** No distinction is made between the direct use of landfill methane (e.g., for heat or steam) and the use of methane for electricity generation. South Carolina's Energy Office is a State Partner of the EPA Landfill Methane Outreach Program (LMOP). Through this partnership, it was determined that 30 landfills in South Carolina can potentially recover methane as an energy source. Based on current LMOP data, however, only 5 sites are generating electricity from landfill methane. According to the 15th edition of *The State of Garbage*, published by Biocycle and Columbia University, out of 3.2 million tons of MSW landfilled in SC in 2004, 228,000 tons of wastes were recovered for energy.[70]

[70] P. Simmons, N. Goldstein, S. M. Kaufman, N.J. Themelis, and J. Thompson, Jr. "The State of Garbage in America." *BioCycle*. April 2006. Accessed on August 24, 2007 from http://www.seas.columbia.edu/earth/wtert/sofos/Simmons_SOG06.pdf

## Implementation Mechanisms

TBD – [CCS drafts based on TWG inputs; this can be developed as they go along, and can start early or late as they prefer; the level of detail can vary on TWG approval]

## Related Policies/Programs in Place

SC Alternative Energy bills establish tax incentives for industrial purchase of equipment to use landfill gas. Legislature passed S.1245, providing manufacturers with tax credits for 25% of cost of landfill gas energy equipment.

A state-owned utility is currently producing approximately 20 MW of electricity in SC from landfill methane gas. SC has six existing landfill methane to energy facilities. One facility provides power directly for manufacturing processes. More are in the pipeline.

## Type(s) of GHG Reductions

**Methane Destruction**: Flaring or production of energy from landfill gas results in the destruction of methane.

**GHGs Reduced via Fossil Fuel Reductions:** Use of landfill gas for generating heat/steam or electricity can offset fossil fuel use (e.g., natural gas, coal), which will reduce emissions of $CO_2$, $CH_4$, and $N_2O$ from the combustion of fossil fuels.

## Estimated GHG Reductions and Net Costs or Cost Savings

TBD – [CCS should provide a worksheet and other reference material as needed for transparency]

**Data Sources:** Data on current landfill operations using methane recovery for energy generation (direct or electric) is taken from the EPA LMOP website.[71] Landfill methane emissions are modeled using the EPA Landfill Gas Emissions Model (LandGEM).[72] CCS used the results of LFG to energy cost modeling performed for a similar policy analysis with EPA's LFG cost model (LFGcost) to estimate the costs for this policy element.[73]

**Quantification Methods:**

*GHG Benefits*

[71] http://www.epa.gov/landfill/proj/xls/lmopdatasc.xls.

[72] The LandGEM User's Guide can be downloaded from: http://www.epa.gov/ttncatc1/dir1/landgem-v302-guide.pdf. The MS Excel-based spreadsheet model can be downloaded from: http://www.epa.gov/ttncatc1/products.html

[73] US EPA Landfill Methane Outreach Program, Landfill Gas Energy Cost Model (LFGcost), Version 1.4. "Summary Report, Pechan for NC GHG Mitigation Plan—Scenario 4, LFGE Project Type: Standard Reciprocating Engine-Generator Set," March 2, 2007; "Summary Report, Pechan for NC GHG Mitigation Plan—Scenario 2, No Section 45 Tax Credit LFGE Project Type: Small Engine-Generator Set," March 2, 2007; "Summary Report, Pechan for NC GHG Mitigation Plan—Scenario 1, LFGE Project Type: Direct Use (0.5 mile pipeline)," March 2, 2007.

The quantification of the GHG benefits of this option will follow the following process:

- Using information from LMOP, establish the percentage of waste in SC that is in flared, LFGTE (landfill gas-to-energy), and uncontrolled facilities.
- Perform two analyses for the GHG benefits using the LandGEM model: one analysis for the GHG benefits assuming that this option (AFW-9) stands alone, and another analysis assuming that the goals of AFW-8 are met.

The quantification of the cost effectiveness of this option will follow the following process:

- Using the results from a previous LFGcost model run, the cost of this option will be estimated based on whether the methane is converted to useable energy by a small engine, through direct use, or a large engine (800kW and greater). CCS will likely assume that the current share of each three energy conversion techniques will remain constant as uncontrolled sites are converted to control sites to meet the policy goal.

**Key Assumptions: [**TBD, as needed on TWG approval]

## Key Uncertainties

TBD – [as needed and approved by the TWGs]

## Additional Benefits and Costs

TBD – [as needed and approved by the TWGs]

## Feasibility Issues

TBD – [as needed and approved by the TWGs]

## Status of Group Approval

Pending – [until CECAC moves to final agreement at meeting #5 or #6]

## Level of Group Support

TBD – [blank until CECAC meeting #5]

## Barriers to Consensus

TBD – [blank until final vote by the CECAC]Sample Draft Policy Option Template

# AFW-10. Water and Wastewater Energy Efficiency Improvements

## Policy Description

The collection and treatment of waste water and the treatment and delivery of drinking water cost around $4 billion per year and makes up 3% of the nation's energy use. Goals of 10-25% energy efficiency would be savings of $400 million to $1 billion which translates into energy savings between 5 and 12.5 billion kWh. The efficiency in energy would also help in reducing GHG emission. Most facilities that carry out these operations were designed during periods of lower energy costs and/or in adequate considerations for GHG emissions to the environment. Simple improvements such as replacement of older equipment can realize savings. Organizations like the American Water Works (AWRA) Association Research Foundation and the Environmental Protection Agency (EPA) have launched initiatives to improve energy efficiency. The AWRA Research Foundation has launched the National Municipal Water and Wastewater Facility Initiative in December 2004 and the EPA has the Energy Star partnership.

## Policy Design

**Goals:** Develop an energy conservation, management and efficiency plan to increase energy efficiency of plant operations by 25%; Use wastewater digester gas to produce energy where feasible.

**Timing:** 15% by 2012; 25% by 2020.

**Parties Involved:** Municipal and private/investor-owned water and wastewater treatment operators, EPA Energy Star program and the AWRA Research Foundation

**Other:** Not applicable.

## Implementation Mechanisms

Policy design considerations include (1) Compliance with current drinking water standards (2) Water quality standards for waste water for discharge to streams/rivers and other water bodies.

The efficiency improvements will come from some or all of the following steps: (a) Variable frequency drives on any machine that has a variable load; (b) Efficient motor systems; (c) Lighting in these facilities are efficient high performance lighting; (d) Maintenance plans for heating and cooling and ventilation; (e) Proper monitoring of dissolved oxygen.

## Related Policies/Programs in Place

South Carolina offers tax incentives for residential / business purchase of solar heating and cooling systems. The tax credit for such equipment is 25% of the installation cost, with a $3500 annual tax credit limit (Amount over the tax can be rolled over to subsequent years).

## Type(s) of GHG Reductions

**$CO_2$:** A portion of electricity used by WWTPs in South Carolina is generated through the combustion of fossil fuels, a process that releases $CO_2$ into the atmosphere. Additionally, methane combusted on-site for the purposes of flaring or energy generation releases $CO_2$, as well as small amounts of $CH_4$ and $N_2O$. However, since $CO_2$ has a lower global warming potential (GWP) than $CH_4$, the practice of combusting methane at WWTPs results in a net reduction of GHGs when expressed in $CO_2e$.

**$CH_4$:** WWTPs that utilize anaerobic digestion as a method of wastewater treatment emit methane. However, as this analysis will show, there is a potential for facilities to capture this methane and combust it to produce heat and electricity.

## Estimated GHG Reductions and Net Costs or Cost Savings

TBD – [CCS should provide a worksheet and other reference material as needed for transparency]

**Data Sources:** This analysis relied on data from EPA's Clean Watershed Needs Survey (CWNS).[74] This survey reports the existing flow, projected flow, and population receiving treatment from the year 2000. These data were applied to aggregate South Carolina population data from the Draft South Carolina Inventory & Forecast. Data regarding the cost and efficiency of specific technologies were compiled from various sources; mostly case studies. There is a lack of data regarding specific energy requirements for WWTPs in SC. CCS is working with DHEC to ensure that the best available data is collected and used in this analysis.

**Quantification Methods:**

*GHG Benefit*

Electricity demand for WWTPs was measured using the CWNS 2000 data to determine what the million gallons per day (MGD) discharge rate was for all residents served by the surveyed facilities. Next, the energy use per million gallons was determined from the median of a survey of 12 WWTPs.[75] The annual BAU WWTP electricity consumption was estimated by taking the product of the per capita discharge rate, the projected population, and the electricity usage (in kWh/MG treated). The emission factor ($MMtCO_2e$/kWh) is available in the SC I&F. The avoided emissions from electricity savings is determined by multiplying the annual efficiency improvement targets by the annual BAU WWTP electricity consumption and the annual electricity emission factor.

Also, any use of anaerobic digestion to reduce energy use and generate energy on-site will reduce emissions. This will be quantified in the same manner as AFW-2, where the volume of methane produced allows for a certain offset of GHG emissions due to the conversion of $CH_4$ to $CO_2$ and the generation of electricity.

*Cost Effectiveness*

[74] US EPA. CWNS 2000 DATA; Ask WATERS Simple Query Tool. http://www.epa.gov/cwns/2000data.htm.

[75] Energy Benchmarking Secondary Wastewater Treatment and Ultraviolet Disinfection Processes at Various Municipal Wastewater Treatment Facilities, prepared for Pacific Gas and Electric, prepared SBW Consulting , Inc., February 2002.

Little information regarding the cost of upgrades is available, with the exception of a few case studies in Vermont. Information regarding the amount of energy used by various processes (i.e. pumping, treatment, lighting, HVAC) at water and wastewater treatment facilities will be helpful in reducing the uncertainty of the results.

**Key Assumptions: [**TBD, as needed on TWG approval]

## Key Uncertainties

TBD – [as needed and approved by the TWGs]

## Additional Benefits and Costs

TBD – [as needed and approved by the TWGs]

## Feasibility Issues

TBD – [as needed and approved by the TWGs]

## Status of Group Approval

Pending – [until CECAC moves to final agreement at meeting #5 or #6]

## Level of Group Support

TBD – [blank until CECAC meeting #5]

## Barriers to Consensus

TBD – [blank until final vote by the CECAC]