MARYLAND
Commission on Climate Change

Agriculture, Forestry, and Waste Management Technical Work Group

Summary List of Priority Policy Options for Analysis

Draft Option #	Draft Policy Option Name	Straw Proposal Volunteers
AFW-1	**Forest Management for Enhanced Carbon Sequestration** (with Mitigation of Forest Loss Due to Insects, Disease, Pests and Invasive Species**)**	James Remuzzi, Eric Sprague, Gary Allen, Joel Dunn, Laura Miller, Elmer Weibley
AFW-2	**Managing Urban Trees and Forests for Greenhouse Gas Benefits** (with Mitigation of Forest Loss Due to Insects, Disease, Pests and Invasive Species)	Gary Allen, Cindy Parker, James Remuzzi, Laura Miller, Elmer Weibley
AFW-3	**Afforestation, Reforestation and Restoration of Forests and Wetlands**	Laura Miller, Gary Allen, James Remuzzi, Joel Dunn
AFW-4	**Protection & Conservation of Agricultural Land, Coastal Wetlands and Forested Land**	James Remuzzi, Eric Sprague, Joel Dunn
AFW-5	**“Buy Local” Programs for Sustainable Agriculture, Wood and Wood Products**	Cindy Parker, (Laura Miller)
AFW-6	**Expanded Use of Forest and Farm Feedstocks and By-Products for Energy Production**	Gary Allen, Chris Rice
AFW-7	**In-State Liquid Biofuels Production**	Eric Sprague, Chris Rice
AFW-8	**Nutrient Trading with Carbon Benefits**	George Kelly, Bob Ensor, Elmer Weibley
AFW-9	**Waste Management through Source Reduction & Advanced Recycling**	Cindy Parker, Ed Dexter

Introduction:

Forests and trees. Their benefits are extensive, complex, and beyond measure. Trees remove carbon dioxide from the air and store carbon in their trunks and branches; trees absorb and filter nitrogen dioxide, sulfur dioxide, ozone, carbon monoxide, and particulate matter less than 10 microns in size; trees release oxygen and intercept rainwater and dust. The process of evapotransporation and shade from trees lowers summertime air and surface temperatures.

Shade and lower surface temperatures reduce the need for air conditioning in buildings thereby reducing the need for the production and transmission of electricity. Reduced energy production reduces emissions of green house gases and carbon from power plants. Shade and lower surface temperatures reduce maintenance needs of infrastructure which, in turn, reduces the conversion of raw materials to asphalt and concrete which reduces the production of green house gases from manufacturing plants and transportation and heavy equipment. Shade and lower surface temperatures reduce the evaporation of chemicals from car engines and reduces the need for air conditioning in cars. This reduces the amount of fuel burned and reduces the emissions from cars. And these are but a few examples.

Sustainable forest and urban forest management is essential to healthy, productive forests and trees that maximize mitigation for green house gases and carbon sequestration. In the face of climate change, it is critical that we do everything within our power to increase the amount and enhance the condition of forests and trees everywhere. Their benefits span arenas making them our single most cost effective tool for mitigating for climate change.

Summary List of Draft Priorities for Analysis

	Policy Option	GHG Reductions ($MMtCO_2e$)			Net Present Value 2008–2020 (Million $)	Cost-Effective-ness ($\$/tCO_2e$)	Level of Support
		2015	2020	Total 2008 2020			
AFW-1	Forest Management for Enhanced Carbon Sequestration (with Mitigation of Forest Loss Due to Insects, Disease, Pests and Invasive Species)						Pending
AFW-2	Managing Urban Trees and Forests for Greenhouse Gas Benefits (with Mitigation of Forest Loss Due to Insects, Disease, Pests and Invasive Species)						Pending
AFW-3	Afforestation, Reforestation and Restoration of Forests ~~and Wetlands~~	0.4	0.6	3.9	112.7	28.88	Pending
AFW-4	Protection & Conservation of Agricultural Land, Coastal Wetlands and Forested Land a. Agricultural land b. Forested land c. Coastal Wetlands	a. b. 2.4 c. NQ	a. b. 2.7 c. NQ	a. b. 30.5 c. NQ	a. b. 851.9 c. NQ	a. b. 27.89 c. NQ	Pending
AFW-5	"Buy Local" Programs for Sustainable Agriculture, Wood and Wood Products						Pending
AFW-6	Expanded Use of Forest and Farm Feedstocks and By-Products for Energy Production						Pending
AFW-7	In-State Liquid Biofuels Production						Pending
AFW-8	Nutrient Trading with Carbon Benefits						Pending
AFW-9	Waste Management through Source Reduction & Advanced Recycling	17.6	29.3	187	-1,154	-6	Pending
	Sector Total After Adjusting for Overlaps[a]						
	Reductions From Recent Actions						
	Sector Total Plus Recent Actions						

Straw Proposal

AFW-1 Forest Management for Enhanced Carbon Sequestration

Policy Description

Healthy, sustainable and productive forests provide a vast array of benefits. Sustainable forest management enhances environmental benefits and increases social and economical benefits, as well. This policy enhances productivity of healthy sustainable forests. Benefits from this option include: increased rates of carbon dioxide (CO_2) sequestration in forest biomass through healthier forests, increased amounts of carbon stored in harvested, durable wood products, and the availability of renewable biomass for energy production.

Practices may include: supplemental planting on poorly stocked lands, age extension of managed stands, thinning and density management, fertilization and wood waste recycling, expanded use of short-rotation woody crops (for fiber and energy), expanded use of genetically preferred species, modified biomass removal practices, and/or fire management and risk reduction.

Programs that reduce populations of invasive and damaging insects, diseases, plants and other pests enhance forest health and long-term sustainability. Reducing pressure from invasive species increases benefits from forests, helps mitigate for GHG emissions and sequester more carbon. Threats from invasive species are increasing in number and severity, especially since forestlands are more vulnerable due cumulative effects of other stressors. Some native species. populations exceed the carrying capacity of the habitat, undermining regeneration efforts, and therefore sustainability. For example, the over-abundance of white-tailed deer places excessive browse pressure on regeneration and understory plants in all forests. *(difficult to quantify effects on emissions and costs as implementation mechanisms and efficacy vary widely)*

Policy Design

Education and outreach especially for citizens and land managers will be an important part of this goal both to underscore importance of forests and to teach best management practices for forests.

Goals:

- Improve sustainable forest management on 25,000 acres of private land by 2020
- Manage XX% of public lands using sustainable management practices by 2020
- As markets are developed, biomass removed through forest management will be used first for long-term storage in durable wood products then for beneficial uses such as bio-fuels and energy. NOTE: The biomass generated from improved management practices is quantified in AFW-1, and the GHG implications of using the increased biomass for durable wood products and energy production is quantification in AFW-5 and AFW-6, respectively.
- (Possible goal) Implement forest certification on XX% of public and private lands by 2020?

Parties Involved: DNR, MDE, MDA, DNR, counties, SHA, Chesapeake Bay Program, NRCS, USFS, private land owners, public land owners, private sawmills, landscaping industry, nursery industry, MD Cooperative Extension and Master Gardeners, and artisan community.

Implementation Mechanisms

- Outreach and education
- Revise FCA
- Support Sustainable Forestry Act
- Legislation restricting sale of priority non-native invasive species
- Outreach and education about invasive species and control methods
- Use offset funds to enhance forest management on private lands and reduce conversion to other land uses
- Develop prioritization of invasive species and identify species of high priority
- Shift decision making efforts to plan ahead for invasive species problems—move towards prevention or proactive management rather than control and reactive treatment
- Develop mechanism to aggregate smaller land holdings to compete in meaningful markets
- Include sustainable forest management in the RGGI Carbon Rule

Related Policies/Programs in Place

Forest Conservation Act

Sustainable Forestry Act

Types(s) of GHG Reductions

CO_2: Enhancement of annual carbon sequestration from forest growth and reforestation through forestry management programs. Removal of fuels that contribute to wildfire emissions. Maintain carbon sequestration through the production of durable wood products. Reduce emissions by reducing use of fossil fuels replaced by energy from woody biomass. Reduce emissions by preventing the release of carbon from dead and dying trees. Reduce wildfire emissions by maintaining healthy forests.

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]

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 MWG moves to final agreement at meeting #5 or #6]

Level of Group Support

TBD – [blank until MWG meeting #5]

Barriers to Consensus

TBD – [blank until final vote by the MWG]

AFW-2 Managing Urban Trees and Forests for Greenhouse Gas Benefits

Policy Description

Healthy, sustainable urban forests are essential to our social, economical, and environmental welfare. This policy option maintains and improves the health and longevity of trees in urban and residential areas. Trees in urban areas avoid emissions from power production, maintenance of built structures and infrastructure, and store carbon. Urban trees contribute to lower summertime temperatures in urban areas reducing and the formation of ground-level ozone and the evaporation and volatilization of organic compounds from vehicles. Also, VOCs, NOx, fine PM, and other pollutants are reduced.

This option increases the utilization of wood recovered from urban trees for energy production or in value-added products for long-term carbon storage.

Also, this option expands the tree canopy in urban areas, encourages species diversity while extending survival and longevity rates; and addresses insects, invasive species and disease in urban forest settings.

Policy Design

Educate the public and legislators on the importance of urban forests for ozone & temperature regulation leading to reduced energy use.

Model numbers are based on American Forests recommendations and what Annapolis has found (Mike Galvin at DNR good contact for this info).

Assume a baseline based on East Coast averages from American Forests if MD doesn't have the data to support a baseline of urban canopy.

Goals:

- Enhance green infrastructure planning including tying green areas together
- Develop incentives to better use urban wood recovery highest order wood product
- Urban tree canopy goals for Maryland will be 40% in urban areas, 50% in residential zones and 30% in commercial areas.

Goals related to Forest Pests and Invasive Species:

- Develop prioritization of invasive species and identify species of high priority
- Shift decision making efforts to plan ahead for invasive species problems—move towards prevention or proactive management rather than control and reactive treatment
- **Timing:** very little time needed to implement

- **Parties Involved:** DNR, MDE, MDA, counties, SHA, Chesapeake Bay Program, NRCS, private land owners, landscaping industry, nursery industry, MD Cooperative Extension and Master Gardeners

Timing: *Need to develop policy specific dates short and long term. Where do we want to be by 2020 and how fast do we want to get there?*

Parties Involved: DNR, MDE, MDA, DNR, counties, municipalities, SHA, Chesapeake Bay Program, NRCS, USFS, private land owners, public land owners, private sawmills, artisan community, landscaping industry, nursery industry, MD Cooperative Extension and Master Gardeners, arborist industry

Other:

Implementation Mechanisms

PLACE HOLDER:

- Outreach and education
- Monitor and report plantings at local level
- Provide enhanced funding from conservation programs like Program Open Space to local jurisdictions to implement policies (like wood recovery and canopy goals) and/or plant trees
- Legislation restricting sale of priority non-native invasive species
- Outreach and education about invasive species and control methods

Related Policies/Programs in Place

Strengthen, fund, and support the Urban Community Forestry Act: Add urban tree canopy goals to Act

Types(s) of GHG Reductions

- **CO_2:** Avoidance of emission of carbon dioxide and associated GHGs through the reduction of heating and cooling needs in urban areas. Reduction of surface temperatures reducing volatilization of gasses from vehicles. Maintaining carbon sequestration by creating durable wood products. Reduce use of fossil fuels by using wood waste for energy.

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]

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 MWG moves to final agreement at meeting #5 or #6]

Level of Group Support

TBD – [blank until MWG meeting #5]

Barriers to Consensus

TBD – [blank until final vote by the MWG]

AFW-3 Afforestation, Reforestation and Restoration of Forests and Wetlands

Policy Description

Increasing forest and tree cover provides additional benefits for mitigation of GHG. This policy option promotes forest cover and associated carbon stocks by regenerating or establishing healthy, functional forests through afforestation (on lands that have not, in recent history, been forested including agricultural lands) and reforestation (on lands with little or no present forest cover) where current beneficial practices are not displaced. Successful establishment requires commitment for as much as 20 years. Forest patches should be sufficient in size to function as a community of trees.

In addition, this policy promotes the implementation of practices such as soil preparation, erosion control, and supplemental planting to ensure conditions that support forest growth. Identify areas, including all wetlands, that are in need of physical intervention to return forest habitats to full vigor. Additional areas of concern are linking islands of fragmented forests to restore function, recovering severely disturbed lands and reversing the effects of continued toxicity.

Policy Design

Carbon sequestration via afforestation is important, but other ancillary benefits provided by forests, in terms of greenspace, quality of life, and avoided emissions are also critical and add to the value of forest land for the community (see Introduction).

Maryland is a member of the Regional Greenhouse Gas Initiative (RGGI) (http://www.rggi.org), which mandates the existence of an inter-state CO2 Budget Trading Program to reduce emissions from the power sector (RGGI applies to fossil fuel-burning plants larger than 25MW). Beginning with implementation of the CO2 Budget Trading Program on January 1, 2009, emissions entities are permitted to use offset projects to meet up to 3.3% of their emissions limitations (this could increase to 5% and 10% in later years). Specific uses of revenues from sale of carbon credits is at the discretion of states.

To be eligible to participate in the Program, an offset project must submit to specific reporting requirements as documented in the RGGI Model Rule (http://www.rggi.org/docs/model_rule_corrected_1_5_07.pdf). In addition, a forest offset project must:

- Be an afforestation project (i.e. land must have been in a non-forested condition for at least ten years prior to commencement of the offset project);
- Be protected in perpetuity via a conservation easement;
- Commit to management in accordance with widely accepted environmentally sustainable forestry practices, designed to promote the restoration of native forests by using mainly native species and avoiding the introduction of invasive nonnative species; and
- (if commercial timber harvest is planned) Enroll in a certification program such as those offered by the Forest Stewardship Council (FSC), Sustainable Forestry Institute (SFI), American Tree Farm System (ATFS), or such other similar organizations.

Additional categories for offset projects may be added to the list of eligible projects, at the discretion of individual states. For example, reforestation projects or forest management projects may eligible to participate in the CO2 Budget Trading Program at some future point.

Goals:

- Establish sufficient acreage in forests to offset loss of 900 acres each month to development, beginning in June 2008 and continuing through December 2020.
- This proposal will use Chesapeake Bay Commission goals where possible. *Connect goals to Chesapeake Bay Forest Conservation directive soon to be released* (**CCS suggestion**: perhaps delete this goal; Forest Conservation Directive applies to forest protection which is covered in AFW-4)
- Include another goal to address increasing wetlands (Non quantified goal).
- **CCS Suggestion**: Establish riparian buffers at a rate of 900 miles/year (50(?) foot width) until 70% of all stream miles in the State are buffered (Chesapeake Bay Forest Conservation Initiative)

Timing: See goals, above.

Timing of implementation depends on funds and policy changes; once trees are planted 6 to 18 years before significant potential for carbon sequestration is predictable (CCS note: The literature does not support this statement. Suggest quantifying with immediate increase in C stocks, per information from Smith et al. 2006 NE-GTR-343 and 1605 b Guidelines). If desired, could also move this text to feasibility section.)

Parties Involved: DNR, counties, SHA, MDA, MDE, Chesapeake Bay Program, NRCS, private land owners

Implementation Mechanisms

PLACE HOLDER:

- Outreach and education
- Green infrastructure plans
- FCMA – tax law program
- Economic incentive to private landowners including promotion of non-traditional products such as hunting leases and passive recreation
- Review fee-in-lieu dollars (amount and use) within the Forest Conservation Act. Fees should be available for easements and set at fair market values. Fee-in-lieu should be used as a last resort and in amounts that make it.
- Allowances from RGGI auctions should be available to for reforestation and restoration.
- Also property and inheritance tax incentives

Related Policies/Programs in Place

PLACE HOLDER: FCA;

Recommend that the Commission for Climate Change and RGGI increase acknowledgment and importance of forests as significant in climate change mitigation

See example from Washington County in implementation of the Forest Conservation Act.

Types(s) of GHG Reductions

CO_2: Increasing annual carbon sequestration from establishing forest ~~growth and~~ cover~~, and restoring wetlands.~~

Estimated GHG Reductions and Net Costs or Cost Savings

- **Data Sources:**
  - USDA Forest Service (USFS) 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).
  - USFS Forest Inventory Analysis data, provided by the USFS for the MD Forestry Inventory and Forecast (Jim Smith, USFS).
  - Walker et al. 2007. Terrestrial carbon sequestration in the Northeast: Opportunities and Costs, Part 3A: Opportunities for Improving Carbon Storage through Afforestation of Agricultural Lands.
- **Quantification Methods:**

A. GHG benefit

Forests planted on land not currently in forest cover will likely accumulate carbon at a rate consistent with accumulation rates of average forest cover in the region. Therefore, C sequestered by afforestation activities was assumed to occur at the same rate as C sequestration in average MD forest. Average C storage was found based on USFS GTR-NE-343 assuming afforestation activity with a forest type distribution of 70% Oak-Pine, 15% Oak-Pine and 15% Loblolly-Shortleaf Pine. This distribution is reflective e of the average forest composition in MD, and is based on USDA Forest Servcie Forest Inventory and Analysis statistics.[1] A 45-year project period was assumed, such that the rate of forest C sequestration under afforestation projects for an average acre in MD was estimated at 1.2 t C $acre^{-1}$ $year^{-1}$ (Table AFW3-1). Forests planted in one year continue to sequester carbon in subsequent years. Thus C storage in a given year is calculated as the sum of annual C sequestration on cumulative planted acreage.

Table AFW3-1. Forest Carbon Sequestration Rates for Afforestation Activity

	MtC/ac (0 yr)	MtC/ac (45 yr)	MtC/ac/yr
Oak-Hickory	0.8	56.2	1.2
Oak-Pine	1.7	48.5	1.0
Loblolly-shortleaf pine	1.7	41.9	0.9
Weighted average			1.2

[1] http://www.fs.fed.us/ne/global/pubs/books/epa/states/MD.htm

The rate of afforestation was estimated at 900 acres/ month, for a total of 10,800 acres afforested annually. In 2008, it was assume that policy implementation would only occur over 7 months (beginning June 2008), so 6,300 acres would be afforested in that year. Between 2008 and 2020, a total of 135,900 acres would be afforested under AFW-3, for a total of 3.9 MMtCO2e stored (Table AFW3-2).

Table AFW3-2. Acreage planted each year under AFW-3, and total C sequestered.

	acres planted this year	acres planted in prior years	C sequestered (MtC/ yr)	C sequestered (MMtCO2e/yr)
2008	6300	0	7256	0.027
2009	10800	6300	19695	0.072
2010	10800	17100	32135	0.118
2011	10800	27900	44574	0.163
2012	10800	38700	57013	0.209
2013	10800	49500	69452	0.255
2014	10800	60300	81891	0.300
2015	10800	71100	94331	0.346
2016	10800	81900	106770	0.391
2017	10800	92700	119209	0.437
2018	10800	103500	131648	0.483
2019	10800	114300	144087	0.528
2020	10800	125100	156527	0.574
total		135900		3.903

B. Economic Costs

Estimated per acre costs for afforestation in Maryland were obtained from Walker et al. (2007), who surveyed state foresters, regional foresters, or other foresters and related specialists in the US Forest Service, universities, and forest companies and reported results on a state-by-state basis. Costs include site preparation, labor, seedlings, and herbivore protection (Walker et al. 2007). Per acre afforestation costs in Maryland were estimated to be $1,180 and $980 for hardwoods and softwoods, respectively. Following the distribution of forest types used to calculate the GHG benefit of forest planting (see above), it was assumed that 70% of the planted forests would be hardwoods with the remainder in softwoods. Thus the weighted average cost to plant an acre of forest in MD was estimated at $1,105. This is a one-time cost incurred in the year of planting. Based on this information,the net present value (NPV) for this option is $112.7 million, with a levelized cost effectiveness of $28.88/ ton C sequestered (Table AFW3-3).

AFW3-3. Economic costs of afforestation.

	Acres planted	Total cost	Discounted cost
2008	6300	$6,961,500	$6,961,500
2009	10800	$11,934,000	$11,365,714
2010	10800	$11,934,000	$10,824,490
2011	10800	$11,934,000	$10,309,038
2012	10800	$11,934,000	$9,818,131
2013	10800	$11,934,000	$9,350,601

2014	10800	$11,934,000	$8,905,335
2015	10800	$11,934,000	$8,481,271
2016	10800	$11,934,000	$8,077,401
2017	10800	$11,934,000	$7,692,763
2018	10800	$11,934,000	$7,326,441
2019	10800	$11,934,000	$6,977,563
2020	10800	$11,934,000	$6,645,298
total	135900		$112,735,545

CCS NOTE: TWG is interested in aligning this goal with RGGI Model Rule. RGGI requires that land enrolled in offset program be protected permanently via easements. Should the cost of easements be included in the assessment of economic cost?

- **Key Assumptions:** See analysis, above.

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 MWG moves to final agreement at meeting #5 or #6]

Level of Group Support

TBD – [blank until MWG meeting #5]

Barriers to Consensus

TBD – [blank until final vote by the MWG]

AFW-4 Protection and Conservation of Agricultural Land, Coastal Wetlands and Forested Land

Policy Description

Land conservation offers an important mechanism to mitigate and adapt to climate change. Deforestation and other land-use changes account for as much as 25 percent of global greenhouse gas emissions. In addition, the increasing rate of sea level rise and associated erosion threaten Maryland's shoreline and associated coastal wetlands, removing another natural sink for greenhouse gases. For these reasons and more, we should protect Maryland's green infrastructure and coastal lands.

The State of Maryland and its partners should map, designate, prioritize and purchase areas/property interests that provide potential retreat for wetlands and wildlife, address shoreline erosion issues and provide ancillary carbon sequestration benefits.

Policy Design

Green infrastructure is our natural life-support system – an interconnected network of natural areas and other open spaces that maintains fully functioning ecosystems, sequesters carbon dioxide, sustains clean air and water, and provides a wide array of benefits to people and wildlife. Green infrastructure planning is a systematic and strategic approach to land conservation (similar to watershed-based planning) used to develop a guide to an open space system.

Implementation for green infrastructure plans include such elements as land acquisition, conservation easements, purchase and transfer of development rights, tax credits and structures, and zoning. The toolbox also includes refining land use planning policies and funding programs to allow users of these tools – governments, non-governmental organizations and private citizens – to more effectively protect Maryland's green infrastructure network.

Goals: Using green infrastructure plans as a guide, leverage funds to protect agricultural lands, forest lands, wetlands and coastal areas.

<u>Agriculture lands</u>: Decrease the conversion of agriculture land to developed land through the protection of 1.2 million acres of productive agricultural lands, to ensure no net loss by 2020.

<u>Forest lands</u>: Retain existing levels of forest cover in Maryland, estimated at 2.6 million acres, past 2020 and protect an additional 250,000 acres of forest by 2020 through legal mechanisms, with more than half in areas of high value to water quality (MD Forest Service)

<u>Wetlands</u>: Assess the capacity of wetland types to sequester or release carbon, then focus protection and restoration efforts on wetland types with the greatest capacity for CO2 sequestration. Next using GIS analysis, predict losses due to climate change and set regional goal for restoration based upon predicted losses and funding availability. (Progress un-quantified)

<u>Coastal lands</u>: Protect priority areas designated for coastal wetland retreat and coastal forest lands using nonstructural shore erosion controls (i.e. living shoreline) – keeping pace with wetland, forest and critical habitat loss due to sea level rise. (Progress un-quantified)

[Goal?]

Timing: Next legislative session. *Are there interim goals before 2020 that could be set?*

Parties Involved: State and quasi-state government agencies including Maryland Department of Planning, non-profit organizations, foundations and individuals.

Other: Before colonization by Europeans, Maryland was 95% forested, the other 5% being marsh around Chesapeake Bay (Besley, 1916 and Powell and Kingsley, 1980). By 2000, forest had decreased to 42.8% of land cover. Similarly, Maryland has lost 50% of its pre-settlement wetlands (Tiner and Burke, 1995). Developed land use reached 509,200 ha in 2000. The Maryland Department of Planning has projected that by 2020 urban land use will increase by more than 25% from 1997 levels, and that forest cover will decrease a further 9% by 2020 from 1997 levels. Agriculture has also been projected to decrease by 9% during the same period. Approximately 31 percent of Maryland's 4,360 mile coastline, which encompasses the Chesapeake Bay, the Coastal Bays, and the Atlantic coast, is currently experiencing some degree of erosion. Maryland loses ~260 acres of tidal shoreline to erosion each year. Accelerating rates of sea level rise combined with increased development along Maryland's coastline tend to prolong and exacerbate shore erosion problems.

Implementation Mechanisms

Watershed-based planning is an important tool to accomplishing the goals below.

Possibly rank POS (Project Open Space) money by GHG benefit. There should be no diversion of land conservation funds from the open space program.

Increase the transfer tax on agriculture/forestry land transfers to non-ag/forestry uses. MD Land Preservation Taskforce suggests doubling that tax on conversion of agricultural lands to development.

Reduce or eliminate transfer taxes for continued ag/forestry uses.

- **Land Preservation Tax Credit – Modify Existing Income Tax Credit for Preservation and Conservation Easements (Md. Code Ann §10-723)**
  - Individuals *and corporations* would be allowed to take a *larger* conservation credit for conveying land located in Maryland for such purposes as historical or conservation preservation, agricultural use, forest use, open space, and natural resource conservation. The credit pool would be capped at $100million per year and prioritized to first accept tax credits in coastal hazard areas.
    - A conservation credit is an income tax credit available to landowners who voluntarily preserve their land through the donation of a conservation easement and or fee title.
    - Landowners with little or no taxable income derive fewer benefits from tax credits than do wealthier landowners with high incomes. To address this issue the credit should be made transferable (not the case under existing law) to other taxpayers for use on Maryland State income tax returns.

- The maximum credit would be raised to $100,000 per year with an unlimited amount eligible for transfer and use by third parties and could be carried forward for 15 years (as is the case under current law).
- The transfer of the credit must be completed before the end of the tax year in order to use the credit for that year and must be registered with the Department of Assessment and Taxation to be valid.
- A cap of $100 million will be placed on the first year of implementation, and will be increased each year by the percentage that the consumer price index (CPI-U) exceeds the previous years CPI-U.
- A fee of 3% of the appraised value of the donated interest will be charged on the sale of land preservation credits.
- Funds derived from this program will cover the cost of program management up to 2% with residual monies used for shoreline restoration/conservation fund.

- **CO2 Budget Trading Program**
  - Prioritize the sequestration of carbon through land conservation or restoration by making a fixed percent of CO2 emissions proceeds from future Maryland carbon markets exclusively available to land conservation projects.
  - Approve Subtitle 26.09 Maryland CO2 Budget Trading Program, with above modification.
- **Blanket Authorization for Local Bond Initiatives**
  - Authorize all County governments (some are presently restricted) to approve local bond initiatives specifically for land conservation and climate change adaptation.
- **Program Open Space (POS) Targeting**
  - One of the State's key implementation tools is Program Open Space (POS), which provides dedicated funds for Maryland's state and local parks and conservation areas. Since the program began in 1969, POS funds have never distributed based upon a project's greenhouse gas benefit. Nevertheless, this should now be a prominent consideration when determining the use of these funds. In addition, given the importance of this program, there should be no diversion of funding from the POS program.
- **Extend the Next Generation Farmland Acquisition Program to Maryland Forest Landowners**
  - Through the Maryland Agriculture and Resource Based Industry Development Corp. (MARBIDCO), provide eligible forest landowners up to 70 percent of the easement value of a property, giving the forester equity for a loan to purchase the property.
  - The forester then has the option of finding a land preservation program to buy the development rights at a higher price within three years, paying back MARBIDCO and pocketing the difference. Otherwise, the state pays back MARBIDCO's investment (POS funds) and takes over the easement (Maryland Environmental Trust).
- **Others**

- Statutory and regulatory changes to cited laws.
- Modify income tax policy regarding land conservation credits, cap credit pool to $100mm. Maximum credit suggested is $100m/year. *(Concept: update Tax Credit program to be more similar to VA to incentivize land conservation.)*
- Generate pool of money from industry off-set allowances; earmark a certain amount specifically for land conservation.
- Encourage local bond initiatives – allow through state authorization.
- Encourage and support right of local governments to hold taxes specifically for conservation.
- Increase the transfer tax on ag/forestry land transfers to non-ag/forestry uses. MD Land Preservation Taskforce suggests doubling that tax on conversion of ag lands to development. Reduce or eliminate transfer taxes for continued ag/forestry uses.

Related Policies/Programs in Place

DNR's Greenprint Program
Program Open Space (POS)
Rural Legacy Program (RLP)
Maryland Agricultural Land Preservation Foundation (MALPF)
Maryland Environmental Trust (MET)
Maryland Historical Trust (MHT)

Types(s) of GHG Reductions

CO_2: Preventing release of carbon from conversion of forests, wetlands, and agricultural lands to development. Maintain annual carbon sequestration from forest growth, thriving wetlands and productive agricultural lands. Reduce urban sprawl thus avoiding additional emissions from vehicle miles traveled.

Estimated GHG Reductions and Net Costs or Cost Savings

- **Data Sources:**

National Resource Inventory (NRI) data for Maryland

The Maryland Agricultural Land Preservation Foundation

Farm and Ranch Land Protection Program

US Forest Service Methods for Calculating Forest Ecosystem and Harvested Carbon with Standard Estimates for Forest Types of the US, General Technical Report NE-343 (also published as part of the Department of Energy 1605(b) Voluntary GHG Reporting Program)

USDA Forest Service Forest Inventory data statistics for Maryland, http://www.fs.fed.us/ne/global/pubs/books/epa/states/MD.htm

- **Quantification Methods:**

Agriculture Lands 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 Maryland data) and assuming that agricultural land protected at an increasing rate up to 2020, where it is assumed there is no net loss of agricultural land.
2. multiplying the soil carbon content (currently assuming 0.017 MMtC per 1000 acres) 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.

Agriculture Lands cost

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 an average of easement acquisition cost per acre from the Greenprint-funded easements purchased by MALPF ($1,281/acre)[2] and Co-Held Rural Legacy Easements ($2,792)[3]. It is further assumed that subsidies are available through the Farm and Ranch Land Protection Program (FRPP)[4] for a 50% cost share. Subsidies received through the FRPP are assumed to reduce the conservation costs by 50%. 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.

Forest Lands GHG Benefit

Carbon savings from this option were estimated from two sources: 1) the amount of carbon that would be lost as a result of forest conversion to developed uses (i.e., “avoided emissions”) and 2) the amount of annual carbon sequestration potential that is maintained by protecting the forest area.

1. Avoided Emissions

[2] Average easement acquisition cost per acre for Greenprint from The Maryland Agricultural Land Preservation Foundation Annual Report for 2002 Financial year

[3] Average easement acquisition cost per acre for Co-Held Rural Legacy Easements from The Maryland Agricultural Land Preservation Foundation Annual Report for 2002 Financial year

[4] 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.

Carbon savings from avoided emissions were calculated using statewide average estimates of total standing forest carbon stocks in Maryland, provided by the USFS as part of the Forest Inventory and Forecast for Maryland (Appendix XX).

Loss of forests to development results in a large one-time surge of carbon emissions. In this case, it was assumed that 100% of the vegetation carbon stocks would be lost in the event of forest conversion to developed uses, with no appreciable carbon sequestration in soils or biomass following development. While soil C may be lost on forest conversion to developed use, soil C loss was excluded from this analysis because soil C dynamics are not included in the baseline calculations for the Inventory and Forecast. A comparison of data from the American Housing Survey with land use conversion data from the Natural Resources Inventory (NRI) suggests that, on average, two thirds of the land area in residential lots is cleared during land conversion. Thus, it was assumed that, during forest conversion to developed use, 100% of the forest vegetation would be lost on 67% of the converted acreage. Using the statewide average C densities from the Maryland FIA results, roughly 27.9 tons C emissions are avoided for every acre of forest preserved in Maryland.

Between 1986 and 1999, roughly 9,643 acres of forest were lost in Maryland annually (FIA statistics). Between 1999 and 2005, there was a net gain in forestland annually of roughly 15,000 acres per year (FIA statistics). Overall, between 1986 and 2005 there was a net forest loss of 2,602 acres annually.

To reach the goal of protecting 250,000 acres by 2020 (with 96,000 acres protected by 2012), an additional 19,250 acres would need to be protected each year between 2008 and 2012, and 19,200 acres would need to be protected between 2013 and 2020.

Table AFW4-1 shows the annual and total acreage targeted by the program and associated avoided emissions that would be generated between 2008 and 2020.

Table AFW4-1. Acreage protected annually and associated avoided emissions under policy implementation.

	Acres protected	Avoided emissions (MMTCO2e)
2008	19200	1.962
2009	19200	1.962
2010	19200	1.962
2011	19200	1.962
2012	19200	1.962
2013	19250	1.967
2014	19250	1.967
2015	19250	1.967
2016	19250	1.967
2017	19250	1.967
2018	19250	1.967
2019	19250	1.967
2020	19250	1.967
total	250000	25.545

2. Annual Sequestration Potential in Protected Forests

A majority of the forests in Maryland are oak-hickory types (63%), with 11% in oak-pine and 10% in natural loblolly-shortleaf pine stands (USDA Forest Service, Forest Inventory and Analysis). The remaining forest land is a mix of elm-ash-cottonwood, oak-gum-cypress, maple beech-birch, and white-red-jack pine. This analysis assumed protected forests would occur in the three predominant forest types, following the proportions in the existing inventory: oak-hickory (70%), oak-pine (15%) and loblolly-shortleaf pine (15%). The calculations in this section of the analysis thus used default carbon sequestration values for these forest types (USFS GTR-343, Tables A3, A4, and A39). Average annual carbon sequestration was calculated for stand ages between 25 and 75 years, assuming that protected forests would span this age range. Average annual sequestration rate was calculated by subtracting non-soil carbon stocks in 75-year-old stands from non-soil carbon stocks in 25-year-old stands and dividing by 50 (Table AFW4-2). Soil carbon density was assumed constant and is not included in the calculation.

Table AFW4-2. Forest carbon sequestration rates in protected forests.

	MtC/ac (25 yr)	MtC/ac (75 yr)	MtC/ac/yr
Oak-Hickory (GTR NE 343 Table A3)	37.7	80.1	0.8
Oak-Pine (GTR NE 343 Table A4)	33.3	68.8	0.7
Loblolly-shortleaf pine (GTR NE 343 Table A39)	29.1	55.6	0.5

The results for annual sequestration potential under policy implementation are given in Table AFW4-3. Forests preserved in one year continue to sequester carbon in subsequent years. Thus, annual sequestration potential includes benefits from acres preserved cumulatively under the program.

Table AFW4-3. Cumulative protected acreage and annual sequestration on protected acreage under policy implementation.

	Cumulative acreage protected	Annual Sequestration (MMtCO2e)
2008	19200	0.055
2009	38400	0.110
2010	57600	0.165
2011	76800	0.220
2012	96000	0.274
2013	115250	0.329
2014	134500	0.384
2015	153750	0.439
2016	173000	0.495
2017	192250	0.550
2018	211500	0.605
2019	230750	0.660
2020	250000	0.715
total	250,000	5.000

3. Overall GHG Benefit of Avoided Land Conversion

The cumulative GHG benefit of avoided forest land conversion (including avoided emissions from reduced conversion as well as annual sequestration in protected forest) was calculated in units of $MMtCO_2e$ (Table AFW4-4). Figure AFW4-1 shows the relative impact of avoided emissions and sequestration in protected acreage.

AFW4-4. Combined effect of avoided land conversion and C storage on protected acreage.

	MMtCO2e/yr
2008	2.017
2009	2.072
2010	2.126
2011	2.181
2012	2.236
2013	2.296
2014	2.351
2015	2.406
2016	2.461
2017	2.517
2018	2.572
2019	2.627
2020	2.682
Total	30.544

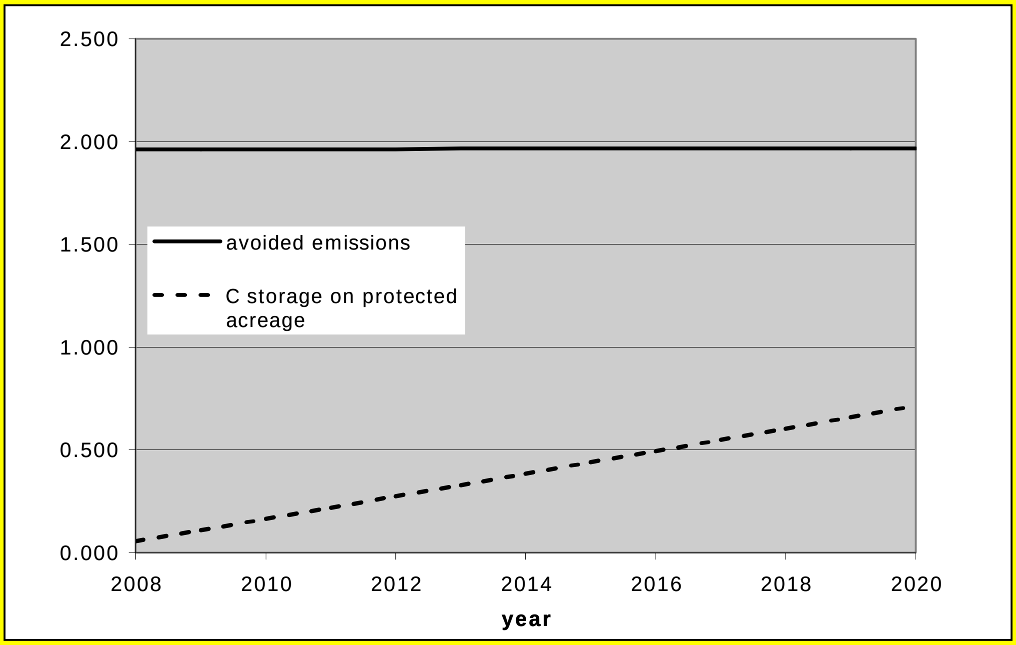

Figure AFW4-1. Relative impact of forest protection and C sequestration on protected acreage.

Forest Lands Cost

Economic costs of protecting forest land were assumed to be the per-acre one-time cost of purchasing conservation easements, at $4,492/acre. This estimate is the recorded average "acquisition cost" in 2006 for easements obtained in Maryland via the Maryland Agricultural Land Protection Foundation.[5]

Net economic costs of protecting forest land are presented in Table AFW4-5. Discounted costs were calculated using a 5% discount rate, with a total Net Present Value of $851.9 million. The cost effectiveness of this option is $27.89/Mt CO_2e avoided.

Table AFW4-5. Economic costs of protecting forest land under Option AFW-4.

	Total cost	Discounted costs
2008	$86,246,400.00	$86,246,400.00
2009	$86,246,400.00	$82,139,428.57
2010	$86,246,400.00	$78,228,027.21
2011	$86,246,400.00	$74,502,883.06
2012	$86,246,400.00	$70,955,126.72
2013	$86,471,000.00	$67,752,291.14
2014	$86,471,000.00	$64,525,991.56
2015	$86,471,000.00	$61,453,325.30
2016	$86,471,000.00	$58,526,976.47
2017	$86,471,000.00	$55,739,977.59
2018	$86,471,000.00	$53,085,692.95
2019	$86,471,000.00	$50,557,802.81
2020	$86,471,000.00	$48,150,288.39

- **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 MWG moves to final agreement at meeting #5 or #6]

[5] Maryland Agricultural Land Preservation Foundation (MALPF), http://www.malpf.info/Tables/2006Values.pdf

Straw Proposal

AFW-5 "Buy Local" Programs for Sustainable Agriculture, Wood and Wood Products

Policy Description

Promote the sustainable production and consumption of locally produced agricultural goods, which displace the consumption of those transported from other states or countries. GHG reductions occur from reduced transportation-related emissions, reduced production-related emissions and enhanced forest health.

Using local wood for construction, furniture or other value-added wood products will enhance local economies while reducing carbon emissions by lowering transportation distances and sequestering carbon in those products.

The use of wood products displaces GHG emissions associated with processing high-energy input materials such as steel, plastic and concrete.

Increased demand for local wood products increases opportunities for forest management treatments that improve forest health and sustainability, thereby improving sequestration and nutrient absorption.

Policy Design

Use definition for sustainable biomass in RPS.

Put leverage on local governments to be part of the solution by ensuring that zoning does not preclude intelligent, sustainable uses that support this objective, such as constraining local value-add mills or limit location/participation in local markets.

Goals:

Farmer's Market: Several projects are being proposed in Maryland that would result in the increase of local farmer's markets in Maryland by 25% by 2015 and 50% by 2020.

Local Produce: Of the food Marylanders consume, 80% would be grown or produced locally by 2050.

Locally Grown and Processed Lumber: The amount of locally grown and processed lumber would displace imported wood by 20% by 2015 and 50% by 2050.

Timing: Startup in 2009 and ramp up to higher levels in 2015 and 2020, consistent with goals.

Parties Involved: Agricultural and wood product primary producers such as Maryland farmers, lumber mills, farmer's market associations and promoters; value-added producers such as Maryland caterers, producers of packaged food for retail, furniture makers, construction businesses, wholesalers and retailers of construction and do-it-youself products, architects and designers; applicable trade associations, Dept. of Agriculture, Dept. of Natural Resources, LEED certification entities.

- **Other:** As needed, identify incentives that encourage the sustainable growing and harvesting of local agricultural and wood products.

Implementation Mechanisms

Specific incentives recommended:
Care must be taken to ensure that the wood and agricultural products are sustainably harvested and produced to create a net carbon sequestration and reduction in emissions.

The following will be included in further discussions:
Maryland has been a LEED (rating system for green building) leader, but hasn't been given credit for wood products, especially local woods as contributing to energy efficiency and carbon emission reductions. This is an issue in several states. TWG needs to put removing that obstacle into Policy Implementation design. MWG is aware of this problem and supports resolution.

Encourage the creation of value-added products from local woods in lieu of shipping raw materials.

Related Policies/Programs in Place

The Maryland Dept. of Agriculture has recently been revitalized and is actively promoting a Buy Local program by (list specific actions and incentives here).

Types(s) of GHG Reductions

CO_2: Extending carbon sequestration in durable wood products and wood construction. Maintaining carbon sequestration in healthy forests. Avoidance of emissions through reduced transportation miles. Avoidance of emissions through reduced use of high-energy input construction 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:**

All data sources, methods and assumptions are based on the Iowa study cited below, and were scaled to Maryland using state population adjustments. The study analyzed the feasibility and effects of shifting transportation distance and mode.

- **Quantification Methods:**

Farmer's Market GHG Benefits
The GHG benefits for the Maryland option are based on a study from Iowa State University[6] which compared miles traveled, fossil fuel used, and carbon dioxide emitted in the transport sector

[6] 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/

of several food systems. The study estimated the fuel use and the CO_2 emissions for transporting (from farm to point of sale) 10% of 28 different fresh produce items using three different food systems: conventional, regional, and local (which includes farmer's markets)

This study was scaled to Maryland using state population adjustments and the relevant percentage of produce to be sourced locally (as determined by the policy goals). This scaling is summarized in Table A. 2006 population estimates were based on U.S. Census Bureau data for Iowa and Maryland[7] – 2,982,085 for Iowa and 5,615,727 for Maryland.

Table A: Fuel consumption and emissions from the Iowa study and the assumed scaling for Maryland.

Food system and type of truck	**Fuel Consumption (gal/year)**	**CO2 emissions (metric tons/year)**
Iowa Conventional semitrailer	368,102	3,807
Iowa local -CSA farmers market small truck (gas)	49,359	439
Maryland Conventional semitrailer	693,193	7,169
Maryland local -CSA farmers market small truck (gas)	92,951	826
Estimated benefit of sourcing 10% locally grown fresh produce	**600,242**	**6,343**

Table B: GHG Savings from increasing the proportion of produce sold at farmer's markets

Year	Increase in local farmer's market	Metric tons CO2e
2008	3%	1,982
2009	6%	3,964
2010	9%	5,946
2011	13%	7,928
2012	16%	9,910
2013	19%	11,892
2014	22%	13,874
2015	25%	15,856
2016	30%	19,028
2017	35%	22,199
2018	40%	25,370
2019	45%	28,542
2020	50%	31,713
		198,205

Farmer's Market Costs

Costs of the program or incentives required to address the envisioned regional approach to increase consumption of local products are yet to be determined. Costs could include the additional costs to incentivize local year-round production of agricultural products, as well as regional storage,

[7] see http://quickfacts.census.gov/qfd/states/19000.html and http://quickfacts.census.gov/qfd/states/24000.html

processing, packaging, and distribution. There are also likely to be cost savings associated with the reduced fuel use in the transportation of non-local produce.

- **Key Assumptions:**

The assumptions and data inputs for the Iowa analysis are assumed to be the same for Maryland, including the distance of food under present (conventional) circumstances and the relative mix of food categories.

Key Uncertainties

- The largest source of uncertainty is whether the region can supply the amount and variety of agricultural products needed to meet the required goals. Significant work will be needed to identify and promote products that can be regionally produced to meet the goals of this policy.
- The relative mix of food categories in Maryland compared to Iowa are not included in this analysis.
- The differences in cost of growing food locally vs. elsewhere (as determined by market) have not been incorporated.
- Incentive system required to make producer and consumer shifts viable

Additional Benefits and Costs

TBD – [as needed and approved by the TWGs]

Feasibility Issues

This analysis only has addressed the farmer's market aspect of the buy local option. Other components of this option are addressing the food system more broadly (i.e. 80% of all food consumed in Maryland). At this stage the information and resources available are not sufficient to capture these benefits and costs. However, it is noted that the potential benefits are significantly greater. The Iowa study notes that the analysis of 10% of 28 produce items "represents less than 1 percent of total food and beverage per capita consumption by weight (not including water) in Iowa". With this in mind, a higher percentage of meats, processed foods, and beverages grown and/or processed locally would result in significantly higher GHG emissions reductions from transport.

Status of Group Approval

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

Level of Group Support

TBD – [blank until MWG meeting #5]

Straw Proposal

AFW-6 Expanded Use of Forest and Farm Feedstocks and Bi-Products for Energy Production

Policy Description

Sustainable forest and farm practices produce bi-products and feed stocks. These are renewable sources of energy. This policy option should increase the utilization of biomass from urban and rural feed stocks including processing byproducts for generation of electricity, thermal energy, and transportation fuels. Additionally, this option should reduce the amount of methane emissions from livestock manure by installing manure digesters and energy recovery projects.

All sources will be considered and implementation strategies will ensure the sustainability of supply. Energy from forest and farm feed stocks and bi-products are used to create heat or power, which offsets fossil fuel-based energy production and associated greenhouse gas (GHG) emissions.

[Note: Need to add reductions from municipal sources of methane.]

Policy Design

All biomass products will be sustainably harvested without depriving soils of important organic components for reducing erosion and maintaining soil nutrients and structure, nor depleting wildlife habitat or jeopardizing future feedstocks in quantity and quality.

Install manure digesters and energy recovery projects in hog and dairy operations.

The lifecycle energy costs and carbon emissions for each feedstock will be evaluated.

Goals:

<u>Agricultural Residues</u>: Increase agricultural residues use for electricity, steam, and heat generation to utilize 10% of available in-state agricultural residue biomass by 2015, 25% of available biomass by 2020.

<u>Forest Residues</u>: Increase forest residues use for electricity, steam, and heat generation to utilize 10% of available biomass by 2015, 25% of available in-state forest residue by 2020.

<u>Energy Crop</u>: Increase the use of energy crop to utilize 50% of available in-state energy crop biomass for electricity, steam, and heat generation by 2020.

<u>Methane from Livestock Manure</u>: By 2020, utilize 50% of available methane from livestock manure for renewable electricity, heat and steam generation.

- Establish certain acreage target for energy crops
- Ensure wood-based energy is given weight equal to wind and solar-based energy in renewable energy credits. (Look at Energy Act and recommend changes if necessary.)
- Many questions about biomass supply remain making projections that drive technology and policy difficult to estimate. Given the current information, it may be too early in the development process to predict goals. Therefore preliminary goals should include

    - Develop benchmarks to implement mechanisms for improvements
    - Developing processes and identifying resources to capture data
    - Develop metrics and methodology of data collection and analysis

- **Timing:**
- **Parties Involved:** Maryland Energy Administration, DNR, MDE, municipalities, power producers (Mirant and Constellation), local electric utilities (distributors), Board of Education, rural community entities (hospitals, community colleges, and universities), Department of Agriculture, Soil Conservation Districts
- **Other:**

Implementation Mechanisms

- Outreach and education
- Change present laws to add incentives (such as Maryland Clean Energy Act)
- Increase incentives through programs such as Fuels for Schools, tax-forgiveness
- Department of General Service could provide equal credit to efficient design, energy efficiently loan programs, etc.

Related Policies/Programs in Place

Modify the Renewable Portfolio Standards requiring local sources of renewable energy

Types(s) of GHG Reductions

- **CO_2, N_2O, CH_4:** Savings occur as a result of reducing methane emissions and the displacement of fossil fuel use in the production of electricity or steam..

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:**

As indicated and referenced below.

- **Quantification Methods:**

Biomass GHG Benefits

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 the majority of electricity generated[8]). With the exception of forest residues (data on available forest residues yet to be determined), the amount of biomass available is taken from the Maryland

[8] Based on eGRID data: Coal 56%, Nuclear 28%, Oil 6.3%, Natural Gas 2.2%, Biomass 1.3%.

Department of Natural Resources Document "The Potential for Biomass Co-firing in Maryland" (March 2006) Maryland Power Plant Research Program.

Agriculture Feedstocks	**Dry Tons**	**Heat content (Mbtu/Ton)[9]**	**Estimated Heat input (Mbtu)**
Corn	262,866	8.3	2,181,788
Wheat	148,723	8.3	1,234,401
Winter Wheat	185,903	8.3	1,542,995
Barley	25,390	8.3	210,737
Total Agriculture Residue	**622,882**		**5,169,921**
Switchgrass	251,019	14.7	3,689,979
Total Agriculture Biomass	**873,901**		**8,859,900**

Biomass is assumed to have a reduction of 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 biomass fuel and the assumed fossil fuel that it is replacing. The assumed costs are identified in Table C below and have been taken from *The Potential for Biomass Co-firing in Maryland*.[10]

Table C: Assumed Costs of Feedstocks

Fuel Type	Cost $/ton delivered	Cost $/MBtu delivered
Agricultural Byproducts	$ 40.00	$ 4.85
Urban waste wood	$ 17.00	$ 1.70
SwitchGrass	$ 47.00	$ 3.20
Mill Residue (Dry)	$ 27.00	$ 1.93
Forest Residue	$ 35.00	$ 3.65
Bituminous Coal	$ 33.84	$ 1.41

The cost is calculated by assuming the replacement of coal with biomass as indicated in Table D and E.in MBtu. The difference in cost of supply between biomass and coal and biomass 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 is presented in Table F.

[9] Heat content of Agricultural byproducts sourced from above DNR report which references EIA (1999) Annual Electric Generator. Heat content for switchgrass is also sourced from the DNR report which references the Energy Information Administration, Annual Energy Outlook 2005, Table H1, February 2005.
[10] Maryland DNR "The Potential for Biomass Cofiring in Maryland" Maryland Power Plant Research Program, March 2006.

Table D. GHG benefits and costs for Agriculture Residue

Year	Percent of Utilization	Ag Residue Biomass (MMBtu)	Avoided Emissions Ag Residue (MtCO2-e)	Ag Residue Cost/Savings	Discounted Cost/Savings
2008	1%	64,624	0.006	$ 222,307	$201,639
2009	3%	129,248	0.012	$ 444,613	$384,074
2010	4%	193,872	0.018	$ 666,920	$548,677
2011	5%	258,496	0.024	$ 889,226	$696,732
2012	6%	323,120	0.030	$ 1,111,533	$829,443
2013	8%	387,744	0.036	$ 1,333,840	$947,935
2014	9%	452,368	0.043	$ 1,556,146	$1,053,261
2015	10%	516,992	0.049	$ 1,778,453	$1,146,406
2016	13%	672,090	0.063	$ 2,311,988	$1,419,360
2017	16%	827,187	0.078	$ 2,845,524	$1,663,719
2018	19%	982,285	0.092	$ 3,379,060	$1,881,587
2019	22%	1,137,383	0.107	$ 3,912,596	$2,074,933
2020	25%	1,292,480	0.122	$ 4,446,132	$2,245,599
			0.620		$15,093,364

Table E. GHG benefits and costs for Energy Crops

Year	Percent of Utilization	Total Energy Crops (MMBtu)	Avoided Emissions, Energy Crops(MtCO2e)	Ag Residue Cost/Savings	Discounted Cost/Savings
2008	2%	73,799.59	0.007	$ 132,101	$119,820
2009	4%	147,599.17	0.014	$ 264,203	$228,228
2010	6%	221,398.76	0.021	$ 396,304	$326,040
2011	8%	295,198.34	0.028	$ 528,405	$414,019
2012	10%	368,997.93	0.035	$ 660,506	$492,880
2013	15%	553,496.90	0.052	$ 990,759	$704,114
2014	20%	737,995.86	0.069	$ 1,321,013	$894,113
2015	25%	922,494.83	0.087	$ 1,651,266	$1,064,421
2016	30%	1,106,993.79	0.104	$ 1,981,519	$1,216,481
2017	35%	1,291,492.76	0.121	$ 2,311,772	$1,351,645
2018	40%	1,475,991.72	0.139	$ 2,642,025	$1,471,178
2019	45%	,660,490.69	0.156	$ 2,972,278	$1,576,263
2020	50%	1,844,989.65	0.173	$ 3,302,531	$1,668,003
Cumulative			**1.01**		$11,527,205

Methane Utilization from Livestock Manure GHG Benefits

Methane emissions (in MMt CO2-e) data from the I&F was used as the starting point to estimate the GHG benefits of capturing and controlling the volumes of methane targeted by the policy and to add in the additional benefit of electricity generation using this captured methane (through offsetting fossil-based generation). 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%[11] was applied to methane emissions from animal manure which was then multiplied by the assumed policy target ramping up to achieve 50% 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 methane to captured 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 Maryland-specific emission factor for electricity production from eGRID (0.587 Mt/MWh).

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

Table G. GHG benefits for methane utilization from livestock manure

Year	Methane Emissions From Dairy, Beef 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	0.066	4%	0.002	0.000	4804	165	0.002
2009	0.066	8%	0.004	0.000	9495	326	0.004
2010	0.065	12%	0.006	0.000	14075	483	0.006
2011	0.065	15%	0.007	0.000	18725	642	0.008
2012	0.065	19%	0.009	0.000	23354	801	0.010
2013	0.064	23%	0.011	0.001	27963	959	0.012
2014	0.064	27%	0.013	0.001	32552	1,117	0.014
2015	0.064	31%	0.015	0.001	37120	1,273	0.016
2016	0.064	35%	0.017	0.001	41668	1,429	0.018
2017	0.064	38%	0.018	0.001	46196	1,584	0.020
2018	0.064	42%	0.020	0.001	50703	1,739	0.022
2019	0.064	46%	0.022	0.001	55191	1,893	0.024
2020	0.063	50%	0.024	0.001	59660	2,046	0.026

Methane Utilization from Livestock Manure Costs

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

The 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 MD-specific data if available.

- **Key Assumptions:**

The fuel mix being replaced by biomass is assumed to be 100% coal.

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 MWG moves to final agreement at meeting #5 or #6]

Level of Group Support

TBD – [blank until MWG meeting #5]

Barriers to Consensus

TBD – [blank until final vote by the MWG/MCCC]

Straw Proposal

AFW-7 In-State Liquid Biofuels Production

Policy Description

Promote sustainable in-state production and consumption of transportation biofuels including ethanol and/or biodiesel from agriculture and/or agroforestry feedstocks to displace the use of fossil fuels. Decrease the use of fossil fuel in the production of these biofuels, which will improve the GHG profile of in-state liquid biofuels production and consumption. Favor the use of cellulosic and non-food source starches in ethanol production and monitor to ensure the sustainability of feedstocks and soil health.

It is understood that promoting biofuel production must be coupled with strong policies to reduce overall transportation fuel consumption if true gains in reducing GHGs is to be achieved. Upon successful implementation of this policy, Maryland consumption of biofuels produced in-state will produce better GHG benefits than these same fuels obtained from a national market due to lower embedded CO_2 (due to transportation of biodiesel, ethanol, other fuels, or their feedstocks from distant sources).

NEED TO CHECK WITH TLU Note: This option is linked with TLU-X on a Low Carbon Fuels Standard. 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:

Develop specific policies based on cellulosic feedstock and value-added by-product study due in December 2007 with production volumes and percent supply use. In the interim, these goals will be used:

Gasoline displacement goals—Achieve in-state cellulosic ethanol production equivalent to offsetting gasoline consumption in the state by 10% in 2015 and 20% in 2020.

Fossil diesel displacement goals—Increase in-state biodiesel production from Maryland feedstocks to offset 10% and 20% of 2005 Maryland petroleum diesel consumption by 2015 and 2020, respectively.

Timing:

Gasoline displacement goals—Incremental increases, up to achieving the full goal by 2020.

Fossil diesel displacement goals—Incremental increases, up to achieving the full goal by 2020.

Parties Involved:

Suppliers of feedstocks, ethanol producers, distributors, communities adjacent to potential facilities, environmental groups, etc. Associated agencies would include: Maryland Department of Natural Resources, MD Energy Administration, Department of Agriculture, Department of Business and Economic Development, etc.

Other:

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. The only ethanol plants proposed in MD are corn-based plants.

There are two biodiesel plants in the state with production totaling 5 million gallons per year.

Implementation Mechanisms

- Develop a state strategy for increasing production of biofuels

    - Based on the MEA/Salisbury University study results of statewide feedstock supply (December 2007), determine opportunities for appropriately-scaled, cellulose-based biofuels facilities
    - Policy options could include:
        - Ensure wood-based energy is given weight equal to wind and solar-based energy in renewable energy credits
            - Change current Renewable Fuels Incentive to include cellulosic ethanol production specifically and give a larger incentive to it
        - Establish tax credit and grant program for E85 filling stations
        - Change existing gasoline specifications in Maryland so that ethanol can be blended into conventional fuel
- Integrate state strategy with regional activities to serve as a market for Maryland supply
- Promote the development of technologies to fractionate black liquor (from paper mills) which can be refined into valuable products using a thermo-chemical or other processes
- Provide financial incentive to research the production of bio-oils from algae grown in wastewater effluents
- Provide "bonus" renewable energy credits for fuels generated in-state or from fuels derived from in-state sources
- Provide access to long-term, low-interest financing for new cellulosic ethanol facilities and supporting infrastructure
- Tax credits and grant programs designed to reduce capital costs of new cellulosic ethanol facilities and supporting infrastructure
- Foster partnerships between users, suppliers, corporations, and adjacent communities
- Provide incentives to communities that provide supply (e.g. woody debris) to biofuels industries
- Provide reliable and predictable supply of cellulose from state lands while ensuring sustainable management
- Incentivize local production of biofuels

Related Policies/Programs in Place

- Renewable Fuels Incentive Act
- Cellulosic feedstock and value-added by-product study (MEA)
    - Feasibility studies
- Renewable Fuels Task Force (created by statute)
- Grants for E85 refueling stations (MEA- but very limited funds- $50,000 total)
- Increase E85 use in State Government

- US DOE construction grants (for bio-fuels plants?)
- Federal loan guarantees (for bio-fuels plants?)
- Potential 2007 Farm Bill programs (need some specifics on this)

Types(s) of GHG Reductions

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

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

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),[12] 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.

Estimated GHG Reductions and Net Costs or Cost Savings

Ethanol

Scenario A – Based on TWG production goals

- GHG reduction potential in 2015, 2020 ($MMtCO_2e$): 2.8, 6.0
- Net Cost per $MtCO_2e$: $82.57

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

- GHG reduction potential in 2015, 2020 ($MMtCO_2e$) 2.17, 2.51
- Net Cost per $MtCO_2e$: $83.85

Biodiesel

Scenario A – Based on TWG production goals

- GHG reduction potential in 2012, 2020 ($MMtCO_2e$): 0.17, 0.41
- Net Cost per $MtCO_2e$: $8.54

[12] 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.

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

- GHG reduction potential in 2012, 2020 (MMtCO_2e): 0.14, 0.16
- Net Cost per MtCO_2e: $16.66

Scenario C – For biodiesel alone: Based on TWG production goals with new technologies meeting in-state feedstock supply shortfalls

- GHG reduction potential in 2012, 2020 (MMtCO_2e): 0.21, 0.66
- Net Cost per MtCO_2e: $6.88

According to studies conducted by the U.S. Department of Energy's Argonne National Laboratory one of the benefits of cellulosic ethanol is that it reduces greenhouse gas emissions (GHG) by 85% over reformulated gasoline. By contrast, starch ethanol (e.g., from corn), which most frequently uses natural gas to provide energy for the process, reduces GHG emissions by 18% to 29% over gasoline.

Data Sources: Data from the MD 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):

BAU Gasoline Consumption

Year	Gasoline consumption (Mmgal/year)
2015	2,989
2020	3,190

The policy design calls for 10% of gasoline consumption to be offset by 2015 from in-state cellulosic ethanol production and 20% offset by 2020. Ethanol has approximately 67% the heat content of gasoline.[13] Therefore, incremental in-state biodiesel production targets are:

Ethanol production needed to meet policy goals

Year	Gasoline consumption to be displaced (Mmgal/year)	Ethanol Production Needed (MMgal/year)
2015	2,989	444
2020	3,190	947

Emission factors from gasoline, starch-based ethanol and cellulosic ethanol are based on the ANL Greet Model.[14] The lifecycle CO_2e emission factor used for gasoline used is 11.74 Mt/1,000

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

gallons, for starch-based ethanol is 9.60 Mt/1,000 gallons, and for cellulosic ethanol is 3.28 Mt/1,000 gallons.[15] The production cost differential for cellulosic versus starch-based ethanol was obtained from the National Renewable Energy Laboratory (NREL).[16]

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

BAU Diesel Consumption

Year	Diesel consumption (Mmgal/year)
2015	817
2020	941

The policy design calls for 10% of the 2005 fossil diesel consumption to be offset by 2015 from in-state production and 20% offset by 2020. In-state BAU production is estimated to be 16 Mmgal/yr in 2015 and 21 Mmgal/yr in 2020 (see below). Biodiesel has approximately 90% the heat content of fossil diesel.[17] Therefore, incremental in-state biodiesel production targets are:

Biodiesel production needed to meet policy goals

Year	Diesel consumption to be displaced (Mmgal/year)	New Biodiesel Production Needed (MMgal/year)
2015	61	51
2020	126	113

The BAU biodiesel production is based upon the current and planned biodiesel capacity of Maryland and assumed 5% growth rate after 2012. See the table below for the existing and planned facilities and capacity in MD:[18]

Facility Name	Status	Capacity (1000 gal)	Feedstock	Misc.
Maryland Biodiesel	In-production	500	Soy	Planned expansion will add 0.5-1 Mmgal/year capacity; goal of 5 Mmgal/year by 2008
Greenlight Biofuels	In-production	4,000	Animal fat with multi-feedstock capacity	Potential to be expanded to 8MMgal/year

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.[19]

---

[14] Ibid.
[15] ANLGreet model emission factor in g/mi x GREET model average fuel economy (100 mi/4.7 gal).
[16] http://www.nrel.gov/technologytransfer/entrepreneurs/pdfs/19_forum/braemar_cellulosic.pdf, slide 21, accessed December 2007
[17] Biomass Energy Data Book, Oak Ridge National Laboratory, http://cta.ornl.gov/bedb/appendix_a.shtml, accessed December 28, 2008.
[18] http://www.biodieselmagazine.com/plant-list.jsp, accessed January 9, 2008; http://biodieselmagazine.com/article.jsp?article_id=1027, accessed January 9, 2008; http://biodieselmagazine.com/article.jsp?article_id=1508&q=greenlight%20biofuels&category_id=19, accessed January 9, 2008

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 policy recommendations. (Need to check with TLU).

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 was used along with the production in each year to estimate GHG reductions.[20] 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 was used to estimate the CO_2e reductions for this option.[21] 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. Lifecycle CO_2e reductions (via displacement of fossil diesel with soybean-derived biodiesel) were estimated by Hill et al. to be 41%. This value is being used by the TLU TWG to estimate the benefit of the biodiesel component of the TLU biofuels option. Hence, this analysis focuses on incremental benefits of in-state feedstocks. It does not include the benefits from transitioning from fossil to standard imported soy.

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 Maryland of about 855 miles.[22] Rail fuel consumption is about 423 ton-miles/gallon.[23] From these inputs, a GHG emission rate of 506 $MtCO_2$/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) and algal oils. Maryland has virtually no production of other oilseed such as cottonseed, canola, or sunflower. 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

---

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

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

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

[22] Google Maps directions, Davenport, Iowa to Maryland; www.maps.google.com.

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

designed to only account for the incremental benefit of in-state feedstock (oil) production using GHG preferential feedstocks. 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 MtCO_2e/MMgal) minus transportation costs, which are assumed to average 100 miles[24], yielding a benefit of 7,207 MtCO2e/MMgal biodiesel over soy-based.

Scenario A

In Scenario A the GHG emissions benefits and cost were calculated as if the TWG goals could be met. For ethanol, it was assumed that there would be enough in-state feedstock requirements. Ethanol production needed was assumed to ramp up from replacing 0% of BAU gasoline consumption in 2007 to 10% in 2015. GHG reductions were estimated by multiplying the cellulosic ethanol by the incremental benefit of using cellulose over corn.

For biodiesel, the table below provides the mix of oil feedstocks assumed in this analysis based on relative proportions of available feedstocks to meet the TWG goals.

Assumed mix of oil feedstocks

Year	Oil Feedstock	Fraction of New Production	MMgal/yr Needed
2015	Soy	0.57	29
2015	Yellow grease	0.29	15
2015	Animal fats	0.14	7
2015	Algal	0.00	0
2015 Total			51
2020	Soy	0.54	61
2020	Yellow grease	0.28	32
2020	Animal fats	0.13	15
2020	Algal	0.05	6
2020 Total			113

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

Scenario B

In Scenario B the upper limit of potential in-state feedstock supplies were estimated and GHG emissions were calculated accordingly.

In-state cellulose supply was estimated from non-harvested cropland and residual biomass residues. The Maryland 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

[24] Max dimension of MD is ~200 miles, 100 miles is 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

cropland and ethanol from cellulose based on DOE and NREL data.[26] 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]

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

It was assumed that it would take five years for production to ramp up to its maximum based on feedstock supplies. This ramp-up is faster than that assumed for Scenario A resulting in higher production and higher emissions savings earlier in the policy period. Consequently, the total emissions reduction and cost effectiveness are very similar for ethanol Scenarios A and B. 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)
2007	0
2008	62,138
2009	124,276
2010	186,414
2011	248,552
2012	310,689
2013	321,418
2014	332,146
2015	342,874
2016	353,602
2017	364,330
2018	375,058
2019	385,786
2020	396,514

[26] http://genomicsgtl.energy.gov/biofuels/2005workshop/2005low_intro.pdf, accessed December 28, 2008; J. Ashworth, NREL, personal communication, 4/06/07.
[27] A Geographic Perspective on the Current Biomass Resource Availability in the United States, A. Milbrandt, NREL, December 2005

Total ethanol production needed to meet TWG goals surpasses the upper bound of in-state potential feedstock by 2012. For scenario B, cellulosic ethanol production was assumed to equal the production maximum based on in-state feedstock resources. GHG deductions in each year were estimated by multiplying production by the incremental benefit of cellulose over corn-based ethanol.

For biodiesel, in-state oilseed feedstock supplies were estimated by measuring the average 2003-2005 Maryland production yields of soybean assuming that 100% of production would go towards biodiesel.[28] Animal fats available were estimated based on the ratio of Maryland 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.[29] 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 Maryland.[30] 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	23,688
Animal fats	5,791
Yellow grease 2015	11,780
Yellow grease 2020	12,329
Algal 2020 - estimated at 5% of feedstock	2,090
total 2015	**41,259**
total 2020	**43,898**

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

Total biodiesel production needed to meet TWG goals surpasses the upper bound of in-state potential feedstock by 2012 and new biodiesel production above BAU needed surpasses in-state potential feedstock by 2014. GHG estimates for this scenario were calculated by multiplying new production of each oil feedstock by the applicable incremental benefit after subtracting BAU production. After 2012, 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.

[28] http://www.nass.usda.gov/Publications/Ag_Statistics/2007/index.asp, accessed January 9, 2008.
[29] http://www.mncee.org/pdf/biomassreport.pdf, accessed January 8, 2008.
[30] 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.

Scenario C

Scenario C is only for biodiesel production and assumes that new technology – in this case, algal – makes up the shortfall between the upper bound of potential in-state feedstock supply and the TWG in-state production goals. To meet the in-state production goals the table below provides the mix of oil feedstocks assumed in this analysis based on transitioning from current feedstock supply proportions to future proportions based on new technology.

Assumed mix of feedstocks with new technology meeting goal shortfall

Year	Oil Feedstock	Fraction of New Production	MMgal/yr Needed
2015	Soy	0.47	24
2015	Yellow grease	0.23	12
2015	Animal fats	0.11	6
2015	Algal	0.18	9
2015 Total			51
2020	Soy	0.21	24
2020	Yellow grease	0.11	12
2020	Animal fats	0.05	6
2020	Algal	0.63	71
2020 Total			113

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.[31] 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.

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.[32] If enacted, this $0.255/gallon premium could cover the additional incentives that are assumed to be needed by the State of Maryland. Obviously, the

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

[32] 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.

federal incentives do not assure that production facilities would locate in MD. These federal incentives have not been factored into the cost estimates for this option.

For biodiesel, costs were estimated using information from an analysis of biodiesel production costs from the US DOE.[33] The value of incentives needed is assumed to be $0.30/gallon - the value of incentives offered in a State of Missouri incentives program.[34] 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.[35] 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: [TBD, as needed on TWG approval]

Key Uncertainties

Cost competitiveness of biofuels will depend on cost of oil

We are awaiting additional studies on Maryland feedstock estimates that may help refine projections.

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."[36]

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

[33] See www.eia.doe.gov/oiaf/analysispaper/biodiesel/index.html; accessed January 2007.
[34] Information on the Missouri Program from www.newrules.org/agri/mobiofuels.html#biodiesel,accessed January 2007.
[35] 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.
[36] http://www.eia.doe.gov/oiaf/analysispaper/biomass.html, accessed December 2007

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 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. The incremental benefit is based on the higher GHG benefits associated with producing ethanol in-state using cellulosic ethanol technology and 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 competion 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 require 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 MWG moves to final agreement at meeting #5 or #6]

Level of Group Support

TBD – [blank until MWG meeting #5]

Barriers to Consensus

TBD – [blank until final vote by the MWG]

Straw Proposal

AFW-8 Nutrient Trading with Carbon Benefits

Policy Description

Nutrient trading, particularly trading between point sources (such as waste water treatment plants) and non-point sources (such as agricultural operations), provides the opportunity to create significant carbon sequestration benefits in Maryland.

Nutrient trading is a flexible and cost-effective means to achieve water quality improvements while also providing significant carbon benefits. Nutrient trading is the transfer of credits created through nutrient reduction from one source, specifically nitrogen and phosphorus. For example, buyers who need to apply or release more nutrients than currently permitted under state-law could obtain credits from sellers who have produced excess nutrient credits. Opportunities exist to apply this policy to also promote and register any carbon reductions associated with nutrient reduction practices. These polices would apply to agriculture, wastewater treatment plants, industrial dischargers, highway contractors and developers.

Besides creating economic benefits, nutrient trading encourages improved efficiency of fertilizer use and other nitrogen-based soil amendments through best management practices and advanced technologies. Advanced technologies such as GPS and GreenSeeker can assist in precision application of nitrogen on crops.

Many of the best management practices that would be incentivized under the nutrient trading program would also result in significant greenhouse gas reductions, such as no-till, conservation tillage, improved irrigation management, conservation buffers, grassland plantings, green infrastructure, afforestation, reforestation and restoration of wetlands.

Note: Excess nitrogen not metabolized by plants can leach into groundwater and/or be emitted to the atmosphere as N_2O which has 310 times the effect as one unit of CO_2. Better nutrient utilization can lead to lower nitrous oxide emissions from run-off.

Policy Design

A cap is currently under development. This is important so as not to overpromise and under-deliver. A cap will also keep costs under control and stay focused on the real goal of reducing GHG rather than just trading for economic gain.

Include acreage benefits and ancillary benefits.

Quantify as best as possible what the saving might be in nutrient reductions.

Goals:

By 2020, increase nitrogen fertilizer efficiency by 20% through the implementation of a nutrient trading scheme.

Have a 2010 target – perhaps that should be the cap?

Further goals could be amount of acreage in program or number of participants or expressed in terms of carbon, such as, carbon will be reduced by xx % by 2020 through sequestration.

The Chesapeake Bay Program has specific reduction goals. Those could be incorporated. Work with MDA to put together some state-wide scenarios and come up with some goals.

Build on existing point source nutrient trading policy document being developed by the Maryland Department of the Environment and develop a complimentary agricultural non-point source policy to include carbon and nutrients. This can be accomplished through regulation and guidance.

- **Work Group:** Agricultural Nutrient Trading Advisory Committee formed and convened November 20, 2007. A draft policy on the non-point source policy is slated for public review by February, 2008.
- **Timing:** Adopt policy by first quarter 2008, stakeholder meetings in spring, and finalize by June, 2008.
- **Parties Involved:** Agricultural and urban non-point sources; municipal wastewater treatment plants; industrial and commercial dischargers; Soil Conservation Districts, Maryland Department of the Environment and Maryland Department of Agriculture.
- **Other:** Septic system owners; other non-point sources; Chesapeake Bay Foundation; University of Maryland; World Resources Institute; Maryland Association of Municipal Wastewater Agencies; Soil Conservation Service.

Implementation Mechanisms

A nutrient/carbon trading policy could be implemented through watershed-based MDE general permit that authorizes trading to occur. A point and non-point source trading policy would be developed and finalized by the MDE and MDA. Any credits produced would be certified and the carbon sequestered could be placed on the state registry and eligible for sale in the event such credits meet applicable standards under emerging state and federal laws/polices on greenhouse gasses.

Consider placing nutrient trading options in permits.

Related Policies/Programs in Place

- Chesapeake Bay Program, Nutrient Trading, Fundamental Principles and Guidance, March, 2001.
- MDE point source trading document, to be issued by end of 2007.
- EPA Water Quality Trading Policy, 2003.

- EPA, Water Quality Trading Took Kit for Permit Writers, 2007.
- Maryland Nutrient Management Act of 1998.
- Virginia Chesapeake Bay Watershed Nutrient Credit Exchange Program, 2005
- Pennsylvania Policy and Guidelines on Trading of Nutrient and Sediment Reduction Credits, 2006.

Types(s) of GHG Reductions

- **N_2O:** reductions occur when nitrogen run-off and leaching are reduced, which leads to the formation and emission of N_2O.
- **CO_2:** Carbon is sequestered through riparian buffers; soil sequestration; and constructed wetlands.
- **CH_4:** Methane is reduced through agricultural best management practices or captured for renewable energy.

Estimated GHG Reductions and Net Costs or Cost Savings

- **Data Sources:** See reference documents regarding carbon sequestration rates from reforestation**.** For example, see the USDA Forestry Inventory and Analysis "look up tables", USDOE's 1605 (b) look up table; Winrock carbon uptake model; Chapman – Richards growth model. See reference documents regarding carbon sequestration rates from no-till practices, such as Va. Tech Rainfall Simulate Research. Also, see research analysis from USDA/ARS in Fort Collins, Colorado, which included analysis on deep core soil samples for baseline data under NLEAP and CEQUESTER models.
- **Quantification Methods:**

A nitrous oxide emission factor for fertilizer use was calculated by dividing the carbon equivalent emissions from fertilizer use in the Maryland inventory and forecast by the fertilizer use for each year.

Then, the CO_2e emission factors for the years 1990–2002 are averaged to provide an estimated emission factor, which is used to calculate the avoided GHG emissions from the proposed increase in fertilizer efficiency resulting from the implementation of the nutrient trading program. The results of the calculations detailed in the preceding discussion are displayed in Table H. Note that this approach does not capture the avoided life cycle GHG reductions that would occur through fertilizer efficiency programs (emissions associated with the production, transport, and energy consumption during application) or other GHG benefits associated with nutrient trading including enhanced soil carbon sequestration.

Historical fertilizer use for Maryland to be obtained from ?(determining appropriate data source for historic MD nitrogen use). This was extrapolated to obtained BAU fertilizer use figures for the policy period. The target fertilizer efficiency improvements were applied to the inferred fertilizer application rate and multiplied by the number of acres to obtain the fertilizer applied under the policy. The difference between BAU fertilizer applied and fertilizer applied under the policy is the target fertilizer reduction, displayed in Table I.

The cost savings associated with using less fertilizer was calculated by multiplying the total fertilizer reduction in each year by the average cost of fertilizer in 2007. The program costs of nutrient trading were estimated as the administrative costs associated with soil testing; costs for staff, overhead, and travel; and guidance document preparation costs less fertilizer savings (negative cost);

- **Key Assumptions:**

Key Uncertainties

Due to weather and drought conditions there may be a discrepancy between estimated and actual nutrient and GHG reductions. This poses some uncertainties in certifying credits in advance of project construction.

Additional Benefits and Costs

Ancillary conservation benefits; wildlife corridors; enhanced biodiversity, and leveraged private capital in ecosystem restoration projects.

Feasibility Issues

Pending –

Status of Group Approval

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

Level of Group Support

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

Barriers to Consensus

- Baseline issues: what are the minimum standards below which credits will be generated
- When should trading occur – now or in the future after implementation of certain regulatory standards?
- Duration of trade: 10 years or life of BMP?

Straw Proposal

AFW-9 Waste Management through Source Reduction & Advanced Recycling

Policy Description

Reduce the volume of waste from residential, commercial, and government sectors through programs that reduce the generation of wastes and enhance reuse of product components and manufacturer's lifetime product responsibility. Reduction of generation at the source reduces both landfill emissions as well as upstream production emissions. Increase recycling and reduce waste generation in order to limit greenhouse gas emissions associated with the production of raw materials.

Reduce methane emissions associated with landfilling by reducing and recycling the biodegradable fraction of waste emplaced.

For products that can not be reused, increase recycling programs, create new recycling programs, provide incentives for the recycling of construction materials, develop markets for recycled materials, and increase average participation/recovery rates for all existing recycling programs to enhance and encourage upcycling (where the remanufactured product is equal to or higher in quality than the original product).

Electronics recycling and recovery of industrial gases from foam products are included.

Policy Design

Baseline needed, specify in 2006 levels.

Be more explicit in what this is trying to accomplish.

Statewide goals in recycling may be harder to accomplish in rural counties with lower volumes of overall waste. Perhaps set or recommend county by county goals. Goal is 50% in urban areas but they seem to be stuck at about 30%.

Categories may be more useful in accurately addressing % of waste stream diverted to recycling, but Maryland lacks break-out information.

- **Goals**: Waste stream will be reduced by 15% in 2012, 25% by 2015, 35% by 2020, and 80% by 2050. Recycling stream will increase by 10% by 2012, 20% by 2015, 30% by 2020, then gradually decrease to 10% by 2050 as more products and their components are reused and new source use also decreases.
- **Timing**: Startup in 2010 and ramp up to higher levels in 2012 and 2015, consistent with goals
- **Parties Involved:** Manufacturers, relevant trade associations, consumer's associations, all state and local agencies, consumers, retail outlets
- **Other:** According to the "2006 Maryland Waste Diversion Activities Report," which provides information on the state's recycling and source reduction activities for the 2005 calendar year, Maryland achieved a recycling rate of 39.2% and an overall diversion rate of 42.6%.[37] Table XX displays diversion data in Maryland from 2001 through 2005.

Table XX: Data from Maryland Recycling Act Annual Reports (Calendar Years 2001-2005)[38]

Item	2001	2002	2003	2004	2005
MRA Rate	37.00%	37.00%	36.80%	35.80%	39.20%
Waste Diversion Rate	39.00%	39.50%	39.60%	38.80%	42.60%
Source Reduction Credit	2.00%	2.50%	2.80%	3.00%	3.40%

[37] Maryland Department of the Environment. 2006. "Maryland Waste Diversion Activities Report: 2006." Accessed on December 20, 2007 from: http://www.mde.state.md.us/assets/document/recycling/2006MWDAR.pdf.
[38] Maryland Department of the Environment. "Maryland Waste Diversion Activities Report." Reports for 2002-2006, reporting data from 2001-2005 all available at: http://www.mde.state.md.us/Land/land_publications/index.asp.

Item	2001	2002	2003	2004	2005
Compostables	617,390	645,230	892,250	853,094	944,358
Glass	47,764	55,481	64,894	71,558	57,889
Metals	220,631	251,703	271,646	302,904	535,195
Paper	948,513	909,447	821,652	861,927	840,644
Plastic	23,149	35,930	24,483	30,663	36,858
Misc.	547,586	558,050	518,599	561,829	518,935
Total MRA Recycling (including organics)	2,405,033	2,455,841	2,593,524	2,681,975	2,933,879
Recycling (excluding organics)	1,787,643	1,810,611	1,701,274	1,828,881	1,989,521
Total MRA Waste Disposed in Landfills and Incinerators*	4,095,056	4,181,567	4,454,096	4,809,575	4,550,506
Total MRA Waste, Including Recycling*	6,500,089	6,637,408	7,047,620	7,491,550	7,484,385
Total Source Reduction*	132,655	170,190	203,018	231,697	263,426
Total Generation, Including Recycling and Source Reduction*	6,632,744	6,807,598	7,250,637	7,723,248	7,747,811
% Change*		2.64%	6.51%	6.52%	0.32%
Annual generation change*	3.36%				
Average annual recycling rate*	37.17%				

*****Calculated from Report Data

These rates are specific to what is referred to as "MRA (Maryland Recycling Act) waste" – the definition of which aligns with the EPA definition of municipal solid waste (MSW). This diversion rate does not take into account waste exported to landfills in neighboring states. The "Annual Report of Solid Waste Management in Maryland – Calendar Year 2005" reports that nearly 1.8 million tons of waste were exported to landfills in Pennsylvania and Virginia, while Maryland landfills received almost 0.3 million tons of waste from New York, Pennsylvania, West Virginia, and the District of Columbia.[39] Considering the net exports of landfill MSW in Maryland, the baseline recycling rate in Maryland was 31.74%.[40]

Table XX: Business-as-Usual Waste Management Projection for Maryland

Item	2005	2010	2012	2015	2020
MSW Managed in-state (3.36%/yr growth 2001-2005)	7,747,811	9,140,922	9,765,948	10,784,525	12,723,659
MSW Imported	286,011	337,438	360,511	398,112	469,695
MSW Exported	1,780,589	2,100,752	2,244,394	2,478,482	2,924,130

[39] Maryland Department of the Environment. 2006. "Annual Report: Solid Waste Management in Maryland – Calendar Year 2005." September 2006. Accessed on December 20, 2007 from: http://www.mde.state.md.us/assets/document/SW_Managed_in_MD_Report_CY_2005.pdf.
[40] Calculation: (2,933,879 tons recycled)/(2,933,879 tons recycled + 1,358,876 tons incinerated + 4,949,636 tons landfilled + 1,780,589 tons exported – 286,011 tons imported).

Item	2005	2010	2012	2015	2020
MSW Exported Waste Recycled	-	-	-	-	-
MD Population (from I&F)	5,561,214	5,907,575	5,989,170	6,113,680	6,326,975
MSW Generation per capita (tons/person)	1.66	1.85	1.95	2.10	2.40
MSW Recycled (37.2% of generation; average from 2001-2005)	2,933,879	3,400,423	3,632,933	4,011,843	4,733,201
MSW Disposed (in-state landfills only)	3,169,045	3,799,850	4,059,671	4,483,090	5,289,181
MSW Disposed in all landfills	4,949,634	5,900,601	6,304,065	6,961,571	8,213,311
Waste to Energy (incinerators) (18% of waste generated)	1,358,876	1,603,212	1,712,834	1,891,480	2,231,582

Implementation Mechanisms

- All government agencies would be required/encouraged to preferentially purchase goods made from reused and recycled materials and goods from manufacturers who take "cradle to cradle" responsibility for their products.
- As needed, identify incentives that encourage the reuse of materials and products, recycling of materials and products, and discourages the single-use waste of products.
- Identify incentives to reduce the amount of raw materials used.
- Increase quality as a means to enhance product longevity with innovative programs to reward manufacturers for quality.
- Identify and phase out any subsidies that discourage waste reduction, reuse of components, or improved quality and longevity of products.
- Work with cross-cutting TWG to include education regarding the wisdom of these policies to all segments of the population including the public.

Comment [BS1]: Moved from "other"

Add discussion of consumer's role in reducing overall consumption. Perhaps look at incentives or disincentives to reduce consumption.

Recently, an area of focus in the solid waste industry has been in increase recycling of organic wastes (lawn & garden waste, food waste, wood, paper, etc.) using different conversion technologies, including composting, anaerobic digestion, or hybrids of these technologies. These tend to be problematic and can have negative impacts not only in smell but in groundwater pollution.

The European Union has WEEE (Waste Electronic and Electrical Equipment) Directive. Manufacturers of all electronic and electrical equipment sold in Europe are required to take back all products when no longer useful or desired by the purchaser. This encourages interchangeable, *reusable parts; elimination of toxins and heavy metals; and maximum recycling, significantly reducing waste.*

Related Policies/Programs in Place

<u>Recent Actions in MD:</u> *No cradle-to-cradle programs in place but MDE does have an aggressive e-cycling program.*

Types(s) of GHG Reductions

- **CH_4:** Methane reductions because of reduced volumes in landfills. Diverting biodegradable wastes from landfills will result in a decrease in methane gas releases from landfills.
- **CO_2:** Upstream Energy Use Reductions – The energy and GHG intensity of manufacturing a product is generally less using recycled feedstocks than from using virgin feedstocks.

Estimated GHG Reductions and Net Costs or Cost Savings

- **GHG Reduction Potential in 2015, 2020 (MMtCO_2e):** 17.6, 29.3
- **Net Cost per MtCO_2e:** -$6
- **Data Sources:** Baseline recycling and waste generation estimates and projections were generated from annual reports on the waste diversion activity and solid waste management in Maryland.[41] The breakdown of the waste disposed in Maryland by type was derived from US-level data provided in the EPA 2005 Waste Characteristics Report.[42] The breakdown of baseline recycled waste in Maryland was derived from the 2006 Maryland Recycling Act Annual Report[43] and the EPA 2005 Waste Characteristics Report. The GHG emission reductions modeled using EPA's Waste Reduction Model (WARM).[44]

[41] Maryland Department of the Environment. 2006. "Maryland Waste Diversion Activities Report: 2006." Accessed on December 20, 2007 from: http://www.mde.state.md.us/assets/document/recycling/2006MWDAR.pdf.

Maryland Department of the Environment. 2006. "Annual Report: Solid Waste Management in Maryland – Calendar Year 2005." September 2006. Accessed on December 20, 2007 from: http://www.mde.state.md.us/assets/document/SW_Managed_in_MD_Report_CY_2005.pdf.

[42] *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.

[43] Maryland Department of the Environment. 2006. "Maryland Waste Diversion Activities Report: 2006." Accessed on December 20, 2007 from: http://www.mde.state.md.us/assets/document/recycling/2006MWDAR.pdf.

[44] 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 emissions reductions from several different waste management practices. WArm is available both as a Web-based calculator and as a Microsoft Excel spreadsheet. WArm calculates and totals GHG emissions of baseline and alternative waste management practices—source reduction, recycling, combustion, composting, and landfilling. The model calculates emissions in MtCe, MtCO_2e, and energy units (million Btu) across a wide range of material types commonly found in MSW. For explanation of methodology, see the EPA report "Solid Waste Management and Greenhouse Gases: A Life Cycle Assessment of Emissions and Sinks," EPA530-R-02-006, at http://epa.gov/climatechange/wycd/waste/SWMGHGreport.html

Information used to build the cost effectiveness estimates was compiled from several sources. Where available, Maryland-specific data were used. However, in many cases, the cost effectiveness quantification relies on information used in previous quantifications of similar options by CCS. Maryland-specific information is from the 2006 MRA Report[45] and a case study from Montgomery County.[46]

- **Quantification Methods:**

  GHG Reductions

  The 2005 MRA recycling rate of 39.2%, along with the reported recycling tonnage of 2,933,879, was used to calculate the quantity of MRA waste disposed: 4,550,506 tons.[47] Based on the total diversion rate (42.6% in 2005), the total estimated waste "generated" – including tons source reduced – is 7,747,881 tons (shown in Table XX above). Data were collected from the MRA annual reports covering the calendar years 2001-2005. The average annual generation change over this time frame is 3.36% and the average annual recycling rate is 37.2%.[48] These historic averages are used to project future baseline generation and recycling. This analysis is performed on the incremental changes in waste diversion, based on the policy goals established by the TWG. Therefore, it is assumed that the baseline source reduction is captured by the projected baseline waste generation. Exports and imports are assumed to increase at the same rate as MSW managed in-state. The baseline - or business as usual (BAU) – projections for waste generation, recycling, landfilling, exports, imports, and incineration are displayed in Table XX in the "Policy Design" section above.

  Table XX shows the projected waste generation and diversion – including recycling and source reduction – through 2020. These projections are formulated by applying the goals set forth by the TWG to the baseline projections from Table XX. Table XX displays the incremental changes in waste generation and diversion as a result of the policy goals; the difference between Tables XX and XX.

Table XX: Waste Management Projection for Maryland – Including Policy Goals

Item	2005	2010	2012	2015	2020
Waste Stream Reduction	0%	5%	15%	25%	35%
Recycling Stream Increase	0%	3%	10%	20%	30%
MSW Generation + Net Exports	9,242,389	10,359,024	9,902,357	9,648,671	9,865,762

[45] Maryland Department of the Environment. 2006. "Annual Report: Solid Waste Management in Maryland – Calendar Year 2005." September 2006. Accessed on December 20, 2007 from: http://www.mde.state.md.us/assets/document/SW_Managed_in_MD_Report_CY_2005.pdf.
[46] Montgomery County, MD. Department of Environmental Protection. "Composting/Grasscycling Program Summary." Accessed on January 11, 2008 from: http://www.montgomerycountymd.gov/deptmpl.asp?url=/content/dep/composting/summary.asp.
[47] Waste captured by the Maryland Recycling Act diversion rate is determined on a county level. However, the MRA excludes scrap metal, landclearing debris, construction and demolition debris, sewage sludge, and hospital wastes. The waste that is captured by the MRA is assumed to align closely with the EPA definition of municipal solid waste. This calculation is performed utilizing the following equation: Waste Disposed = MRA Recycling * (1 – Recycling %)/(Recycling %)
[48] The MRA considers organics composting as a part of the recycling rate. The assumption for this analysis is that all "organic" material will be composted.

Item	2005	2010	2012	2015	2020
MSW Generation w/o net exports (based on Source Reduction Goals)	7,747,811	8,683,876	8,301,056	8,088,394	8,270,379
MSW Generation per capita (tons/person)	1.66	1.75	1.65	1.58	1.56
Net MSW Exports (to out-of-state landfills)	1,494,578	1,675,148	1,601,301	1,560,278	1,595,383
MSW Source Reduced	-	545,212	1,747,475	3,216,224	5,312,333
MSW Recycled	2,933,879	3,513,771	3,996,226	4,814,212	6,153,162
MSW Disposed (in-state landfills only)	3,455,056	3,636,135	3,027,587	2,302,732	1,489,039
Total MSW Landfill disposal	4,949,634	5,311,283	4,628,888	3,863,010	3,084,422
Waste to Energy (29.7% of waste disposed)	1,358,876	1,533,970	1,277,243	971,450	628,178

Table XX: Incremental Diversion Under Policy Goals

Item	2005	2010	2012	2015	2020
MSW Recycled	-	204,025	363,293	802,369	1,419,960
MSW Source Reduced	-	981,381	1,747,475	3,216,224	5,312,333
MSW Landfilled	-	-980,777	-1,675,177	-3,098,562	-5,128,890
MSW Incinerated (WTE)	-	-204,630	-435,591	-920,031	-1,603,404
Incremental Diversion (tons)	-	1,185,407	2,110,768	4,018,592	6,732,294
Incremental Diversion (%)	-	10.9%	18.1%	31.2%	44.4%

The waste generated in Maryland is broken down into six major categories: paper, organics, mixed plastic, metals, glass, and other. Where further categorization information was available, the waste generated within each of these categories is broken down further. Table XX shows the composition of waste generated under the BAU and policy scenarios.

Of the six categories displayed in the breakout in Table XX; paper, organics, mixed plastic, and metals may be categorized further with the information currently available. Glass is considered to be its own category within WARM, and “other” is assumed to be represented by the WARM category, “mixed recyclables.” Table XX shows the breakdown of waste that is disposed in landfills or incinerator facilities, both in the BAU and policy scenarios. The baseline waste breakdown for each waste type is calculated from the amount of the waste type disposed and the total amount disposed in each category.[49]

The share of total waste generated for each category is multiplied by the total waste landfilled to determine the baseline quantity of waste landfilled for each category. The categories for which further categorization information is available (all except glass and other) are further

[49] Maryland Department of the Environment. 2006. “Annual Report: Solid Waste Management in Maryland – Calendar Year 2005.” September 2006. Accessed on December 20, 2007 from: http://www.mde.state.md.us/assets/document/SW_Managed_in_MD_Report_CY_2005.pdf.

broken out by multiplying the total quantity of waste landfilled for each category by the share of generation for each waste type. For example: the baseline landfill disposal projection for 2020 is 8,213,311 tons. To estimate the tons of corrugated cardboard landfilled under the BAU scenario, multiply this number by 34.2% and multiply the result of this product by 31.5%. The result is the projected amount of corrugated cardboard landfilled in 2020 under the baseline scenario (884,820 tons). The process for estimating the characterization of waste incinerated is identical to the methodology used to estimate the characterization of waste landfilled.

Table XX: Waste Generation Characteristics[50]

Category	Baseline Composition (BAU)	2015 Policy Composition	2020 Policy Composition
Paper	34.2%	23.1%	10.3%
Organics	25.0%	41.3%	59.9%
Mixed Plastic	11.8%	11.7%	11.6%
Metals	7.6%	5.4%	3.4%
Glass	5.5%	4.1%	2.7%
Other (assumed mixed reyclables)	15.9%	14.5%	12.0%

Table XX: Baseline and Policy Waste Characterization

Waste Type	BAU	2015 Policy	2020 Policy
% of Discarded Paper			
Corrugated Cardboard	31.5%	34.0%	49.5%
Magazines/Third Class Mail	12.6%	13.9%	20.5%
Newspaper	3.2%	2.9%	3.8%
Office Paper	5.9%	6.4%	9.2%
Phonebooks	1.3%	1.4%	2.1%
Textbooks	2.0%	2.2%	3.3%
Other (assumed mixed paper, broad)	43.5%	39.2%	11.6%
% of Discarded Organics			
Food Waste	70.0%	70.0%	70.0%
Yard Trimmings	30.0%	30.0%	30.0%
% of Discarded Plastics			
HDPE	24.9%	18.9%	12.6%
LDPE	29.0%	22.1%	14.7%
PET	9.7%	7.3%	4.8%
Other (assumed mixed plastics)	36.4%	51.6%	67.9%
% of Discarded Metals			
Aluminum Cans	58.2%	58.2%	58.2%

[50] *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	BAU	2015 Policy	2020 Policy
Steel Cans	41.8%	41.8%	41.8%

The baseline composition of recycled waste is derived from the data presented in the MRA report on diversion activities over the 2005 calendar year (seen in Table XX).[51] The further characterization of waste recycled in Maryland is estimated based on national data from the 2005 EPA Waste Characteristics report (Table XX).[52]

The share of total waste for each category is multiplied by the total waste recycled to determine the baseline quantity of waste recycled for each category. The categories for which further categorization information is available (all except glass and other) are further broken out by multiplying the total quantity of recycling for each category by the share of recycling for each waste type. For example: the baseline recycling projection for 2020 is 4,733,201 tons. To estimate the tons of corrugated cardboard recycled under the BAU scenario, multiply this number by 29.0% and multiply the result of this product by 50.1%. The result is the projected amount of corrugated cardboard recycled in 2020 under the baseline scenario (687,687 tons).

Table XX: Recycled Waste Characteristics

Category	Baseline Recycling (BAU)	2015 Policy Recycling	2020 Policy Recycling
Paper	29.0%	29.6%	29.8%
Organics	32.0%	31.2%	30.9%
Mixed Plastic	1.0%	2.2%	2.7%
Metals	18.0%	6.6%	2.7%
Glass	2.0%	0.7%	0.3%
Other (assumed mixed recyclables)	18.0%	29.7%	33.6%

Table XX: Baseline and Policy Recycling Characterization

Waste Type	BAU	2015 Policy	2020 Policy
% of Discarded Paper			
Corrugated Cardboard	50.1%	17.9%	7.3%
Magazines/Third Class Mail	7.3%	2.6%	1.1%
Newspaper	25.5%	9.1%	3.7%
Office Paper	9.8%	3.5%	1.4%
Phonebooks	1.0%	0.4%	0.1%
Textbooks	1.0%	0.4%	0.1%
Mixed Paper, Broad	5.3%	66.1%	86.2%
% of Discarded Organics			

[51] Maryland Department of the Environment. 2006. "Annual Report: Solid Waste Management in Maryland – Calendar Year 2005." September 2006. Accessed on December 20, 2007 from: http://www.mde.state.md.us/assets/document/SW_Managed_in_MD_Report_CY_2005.pdf.
[52] *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.

Food Waste	70.0%	70.0%	70.0%
Yard Trimmings	30.0%	30.0%	30.0%
% of Recycled Plastics			
HDPE	40.6%	6.6%	2.2%
LDPE	10.8%	1.8%	0.6%
PET	42.2%	6.9%	2.3%
Other (assumed mixed plastics)	6.4%	84.7%	94.8%
% of Recycled Metals			
Aluminum Cans	31.5%	31.5%	31.5%
Steel Cans	68.5%	68.5%	68.5%

The limitations of the WARM model preclude one from applying the 35% reduction in generation by 2020 (henceforth, source reduction) across the board. WARM does not accept source reduction as an input for mixed paper, food waste, yard trimmings, mixed plastics, or mixed recyclables. The application of the source reduction goal to the remaining waste types results in a negative amount of waste landfilled and/or incinerated for many categories. Therefore, it is necessary to achieve the source reduction goal by assuming that only materials where source reduction is an acceptable WARM input are source reduced. This assumption explains why the shares of recycled waste for mixed paper, mixed plastics, mixed recyclables (other) increased over the policy period. This assumption also explains the decrease in the share of disposed (landfill and incinerator) waste over the policy period. The composition of waste that is source reduced is displayed in Table XX.

Table XX: Composition of Waste "Source Reduced"

Waste Type	% of Total SR 2015	% of Total SR 2020
Glass	10.4%	10.4%
HDPE	5.0%	5.0%
LDPE	5.6%	5.6%
PET	2.2%	2.2%
Corrugated Cardboard	28.1%	28.1%
Magazines/Third Class Mail	8.5%	8.5%
Newspaper	7.2%	7.2%
Office Paper	5.3%	5.3%
Phonebooks	0.9%	0.9%
Textbooks	1.3%	1.3%
Aluminum Cans	11.3%	11.3%
Steel Cans	14.2%	14.2%

The following list describes step-by-step the methods used to estimate the levels of recycling, source reduction, landfill disposal, and incineration disposal under the policy scenario:

1. Estimate the waste generated for each waste type under the baseline scenario. This may be accomplished by multiplying the total generation (including net exports) by the share of generation of each category and the share of each category's generation by the share of each waste type within the category (except for glass and other, which are single-type

categories). The alternate method is to take the sum of the calculated baseline waste landfilled, incinerated, and recycled (methods for these calculations listed above).

2. Calculate the tons source reduced for each waste type where source reduction is a valid WARM input.
   a. Determine the source reduction multiplier for each of these waste types. This is accomplished by dividing the total quantity of waste source reduced in each given year by the sum of the total baseline waste generation over all of these waste types.

Table XX: Source Reduction Multiplier

	2010	2012	2015	2020
Source Reduction as a % of WARM SR Categories' BAU Generation	11.75%	35.24%	58.73%	82.22%

   b. Take the product of the source reduction multiplier and the baseline waste generation for each waste type calculated in Step1.
   c. Multiply the tons source reduced for each waste type by one plus the share of baseline tons disposed that is landfilled. This share is equal to the tons landfilled divided by the total tons disposed in incinerators or landfills. The result is the source reduction that diverts waste specifically from landfills.
   d. Multiply the tons source reduced for each waste type by one plus the share of baseline tons disposed that is incinerated. This share is equal to the tons incinerated divided by the total tons disposed in incinerators or landfills. The result is the source reduction that diverts waste specifically from incinerators.
3. Calculate the total tons of recycling for each category under the policy scenario.
   a. Determine the recycling multiplier for each waste type. This is accomplished by dividing the tons to be recycled under the policy scenario by the total BAU waste generation.

Table XX: Recycling Multiplier

	2010	2012	2015	2020
Incremental Recycling as a % of All Categories' BAU Generation	1.04%	3.12%	6.24%	9.36%

   b. Subtract the BAU generation of each waste type in each year from the amount of waste source reduced for each waste type in each year to determine the remainder of waste that must be managed through recycling, landfilling, or incineration.
   c. For each of the waste types that are "source reduced," multiply the remainder of waste to be managed after source reduction by the share of waste generation recycled under the BAU scenario (tons recycled, divided by the sum of tons recycled, landfilled, and incinerated). Multiply this product by one plus the

recycling multiplier to determine the number of tons recycled each year under the policy scenario.

i. To calculate the policy recycling (composting) tonnage for organics, multiply the baseline generation for each waste type by the recycling multiplier and add the BAU recycling tonnage.

ii. To calculate the policy recycling for mixed paper and mixed plastic, first find the total amount of waste recycled in the paper and plastic categories under the policy scenario. This is done by multiplying the recycling multiplier by the tons generated for each of these categories, then adding the BAU tonnage recycled for each category. Next, subtract from this total the sum of the tons recycled for source reduced waste types within these categories.

iii. The policy scenario level of mixed recycling is equal to the total waste recycled under the policy scenario less the tons recycled under the policy scenario for all of the other categories.

d. Calculate the incremental recycling diversion from landfills by multiplying the difference between the policy scenario recycling and BAU scenario recycling for each waste type by the share of baseline tons disposed that are landfilled (see Step 2c).

e. Calculate the incremental recycling diversion from incinerators by multiplying the difference between the policy scenario recycling and BAU scenario recycling for each waste type by the share of baseline tons disposed that are incinerated (see Step 2d).

4. Subtract the results of Steps 3c and 4d from the BAU tons landfilled to determine the tons landfilled for each waste type under the policy scenario.

5. Subtract the results of Steps 3d and 4e from the BAU tons incinerated to determine the tons incinerated for each waste type under the policy scenario.

The BAU and policy scenario waste management projections for each waste type are entered into EPA's WAste Reduction Model (WARM) for the years 2015 and 2020. WARM is a static model; so only one year's inputs may be entered per run. Table XX and XX show the WARM inputs for the 2020 baseline (BAU) and policy scenarios, as they would appear in the WARM workbook.

Table XX: 2020 Baseline WARM Inputs

Material	Tons Generated	Tons Recycled	Tons Landfilled	Tons Combusted	Tons Composted
Aluminum Cans	730,371	268,373	363,291	98,707	NA
Steel Cans	915,417	583,604	260,920	70,893	NA
Copper Wire					NA
Glass	669,133	94,664	451,732	122,737	NA
HDPE	326,109	19,217	241,324	65,568	NA
LDPE	362,536	5,112	281,060	76,365	NA
PET	139,526	19,974	94,010	25,543	NA

Material	Tons Generated	Tons Recycled	Tons Landfilled	Tons Combusted	Tons Composted
Corrugated Cardboard	1,812,915	687,687	884,820	240,408	NA
Magazines/Third-class Mail	550,293	100,202	353,928	96,163	NA
Newspaper	464,329	350,020	89,886	24,422	NA
Office Paper	345,275	134,518	165,728	45,029	NA
Phonebooks	60,164	13,726	36,516	9,922	NA
Textbooks	85,169	13,726	56,179	15,264	NA
Dimensional Lumber					NA
Medium-density Fiberboard					NA
Food Scraps	2,888,093	NA	1,437,330	390,527	1,060,237
Yard Trimmings	1,237,754	NA	615,998	167,369	454,387
Grass		NA			
Leaves		NA			
Branches		NA			
Mixed Paper (general)	1,626,636	72,749	1,221,894	331,992	NA
Mixed Paper (primarily residential)					NA
Mixed Paper (primarily from offices)					NA
Mixed Metals					NA
Mixed Plastics	451,658	3,029	352,778	95,851	NA
Mixed Recyclables	2,512,714	851,976	1,305,917	354,822	NA
Mixed Organics		NA			
Mixed MSW		NA			NA
Carpet					NA
Personal Computers					NA
Clay Bricks		NA		NA	NA
Aggregate				NA	NA
Fly Ash				NA	NA

Table XX: 2020 Policy WARM Inputs

Material	Baseline Generation	Tons Source Reduced	Tons Recycled	Tons Landfilled	Tons Combusted	Tons Composted
Aluminum Cans	730,371	600,500	52,185	61,088	16,598	NA
Steel Cans	915,417	752,642	113,482	38,761	10,532	NA
Copper Wire						NA
Glass	669,133	550,151	18,407	79,086	21,488	NA
HDPE	326,109	268,122	3,737	42,660	11,591	NA
LDPE	362,536	298,072	994	49,910	13,561	NA
PET	139,526	114,716	3,884	16,455	4,471	NA
Corrugated	1,812,915	1,490,552	133,721	148,339	40,304	NA

Material	Baseline Generation	Tons Source Reduced	Tons Recycled	Tons Landfilled	Tons Combusted	Tons Composted
Cardboard						
Magazines/Third-class Mail	550,293	452,443	19,484	61,623	16,743	NA
Newspaper	464,329	381,764	68,061	11,405	3,099	NA
Office Paper	345,275	283,880	26,157	27,709	7,529	NA
Phonebooks	60,164	49,466	2,669	6,314	1,715	NA
Textbooks	85,169	70,025	2,669	9,810	2,665	NA
Dimensional Lumber						NA
Medium-density Fiberboard						NA
Food Scraps	2,888,093	NA	NA	1,224,866	332,800	1,330,428
Yard Trimmings	1,237,754	NA	NA	524,943	142,629	570,183
Grass		NA	NA			
Leaves		NA	NA			
Branches		NA	NA			
Mixed Paper, Broad	1,626,636	NA	1,582,467	34,732	9,437	NA
Mixed Paper, Resid.		NA				NA
Mixed Paper, Office		NA				NA
Mixed Metals		NA				NA
Mixed Plastics	451,658	NA	158,450	230,564	62,645	NA
Mixed Recyclables	2,512,714	NA	2,066,183	351,128	95,403	NA
Mixed Organics		NA	NA			
Mixed MSW		NA	NA			NA
Carpet						NA
Personal Computers						NA
Clay Bricks			NA		NA	NA
Aggregate		NA			NA	NA
Fly Ash		NA			NA	NA

The WARM model runs yielded the GHG benefits reported at the beginning of this section: 17.6 $MMtCO_2e$ reduced in 2015 and 29.27 $MMtCO_2e$ reduced in 2020. To estimate the cumulative emissions through 2020, the emissions reductions are assumed to increase linearly from 0 in 2009 to 17.6 $MMtCO_2e$ in 2015 and from 17.6 $MMtCO_2e$ in 2015 to 29.3 $MMtCO_2e$ in 2020. Table XX displays these results.

Table XX: Overall Policy Results – GHG Reductions

Year	Avoided Emissions (MMtCO2e)	Incremental Waste Diversion (tons)	Incremental Source Reduction (tons)	Incremental Recycling (tons)	Avoided Landfill Emplacement (tons)	Avoided WTE Emplacement (tons)	Avoided Exported Waste (tons)
2009	-	-	-	-	-96,742	96,742	0
2010	2.93	658,559	545,212	113,347	-589,318	-69,241	-88,166
2011	5.86	1,361,404	1,127,087	234,317	-1,114,909	-246,495	-182,260
2012	8.80	2,110,768	1,747,475	363,293	-1,675,177	-435,591	-282,582

Year	Avoided Emissions (MMtCO2e)	Incremental Waste Diversion (tons)	Incremental Source Reduction (tons)	Incremental Recycling (tons)	Avoided Landfill Emplacement (tons)	Avoided WTE Emplacement (tons)	Avoided Exported Waste (tons)
2013	11.73	2,708,292	2,207,615	500,678	-2,121,085	-587,207	-356,991
2014	14.66	3,343,612	2,696,722	646,890	-2,595,085	-748,527	-436,084
2015	17.59	4,018,592	3,216,224	802,369	-3,098,562	-920,031	-520,093
2016	20.15	4,502,594	3,590,312	912,281	-3,460,875	-1,041,719	-580,586
2017	22.71	5,014,599	3,985,921	1,028,678	-3,844,049	-1,170,550	-644,559
2018	25.27	5,555,945	4,404,073	1,151,871	-4,249,078	-1,306,867	-712,179
2019	27.83	6,128,024	4,845,839	1,282,185	-4,676,998	-1,451,027	-783,616
2020	29.27	6,732,294	5,312,333	1,419,960	-5,128,890	-1,603,404	-859,052
Totals	**186.80**	**42,134,683**	**33,678,812**	**8,455,871**	**-32,650,768**	**-9,483,916**	**-5,446,169**

Cost Effectiveness

Source Reduction. A net cost for the State to implement source reduction programs of $1 per capita is assumed.[53] In addition to the program costs to the State, other cost elements include the avoided costs for collecting and transporting the waste to a landfill or other disposal site. For the purposes of this analysis, it was assumed that the waste would have been landfilled, so the landfill tipping fee, estimated at $52/ton, is avoided.[54] CCS assumed that the cost for collecting the waste would not be avoided, since weekly collection of the remaining household/business waste would still be needed. Table XX provides a summary of the costs estimated for the source reduction element of this policy. Cumulative reductions (estimated from WARM results) are about 169 MMtCO_2e through the policy period. A cost effectiveness of -$7 Mt$CO_2$e was calculated along with an NPV of -$1,174 million.

Table XX: Cost analysis results for source reduction

Year	Tons Reduced	Avoided Landfill Tipping Fee (2006$MM)	Program Costs (2006$MM)	Net Source Reduction Costs (2006$MM)	Discounted Costs (2006$MM)	GHG Reductions (MMtCO2e)	Cost Effectiveness ($/MtCO2e)
2009	-	$0.00	$0.00	$0.00	$0.00	0.00	
2010	545,212	$28.35	$5.91	-$22.44	-$21.37	2.66	
2011	1,127,087	$58.61	$5.95	-$52.66	-$47.76	5.32	
2012	1,747,475	$90.87	$5.99	-$84.88	-$73.32	7.98	
2013	2,207,615	$114.80	$6.03	-$108.77	-$89.48	10.65	
2014	2,696,722	$140.23	$6.07	-$134.16	-$105.12	13.31	
2015	3,216,224	$167.24	$6.11	-$161.13	-$120.24	15.97	

[53] **Not a MD-specific estimate. Seek additional input from TWG.** The source reduction program cost is a preliminary estimate that is consistent with costs assumed in similar options considered by CCS projects in WA and CO.

[54] Maryland Department of the Environment. 2006. "Annual Report: Solid Waste Management in Maryland – Calendar Year 2005." September 2006. Accessed on December 20, 2007 from: http://www.mde.state.md.us/assets/document/SW_Managed_in_MD_Report_CY_2005.pdf.

Year	Tons Reduced	Avoided Landfill Tipping Fee (2006$MM)	Program Costs (2006$MM)	Net Source Reduction Costs (2006$MM)	Discounted Costs (2006$MM)	GHG Reductions (MMtCO2e)	Cost Effectiveness ($/MtCO2e)
2016	3,590,312	$186.70	$6.16	-$180.54	-$128.31	18.27	
2017	3,985,921	$207.27	$6.20	-$201.07	-$136.09	20.57	
2018	4,404,073	$229.01	$6.24	-$222.77	-$143.60	22.87	
2019	4,845,839	$251.98	$6.28	-$245.70	-$150.84	25.16	
2020	5,312,333	$276.24	$6.33	-$269.91	-$157.81	26.38	
				-$1,684.03	**-$1,173.95**	**169.1**	**-$6.94**

Recycling. The net cost of increased recycling rates in Maryland was estimated by adding the increased costs of collection for two-stream recycling, revenue obtained for the value of recycled materials, and avoided landfill tipping fees. The additional cost for separate curbside collection of recyclables is $2.50/household/month, or $30/household/year.[55] Dividing this number by the incremental recycling per capita in 2020[56] times the average household size of 2.61[57] yields the maximum collection cost of $51/ton. The capital cost of additional recycling facilities in Maryland is $255 million.[58] Annualized over the10 year policy period at 5% interest, the capital cost is $16.5 million per year. The avoided cost for landfill tipping is $52/ton.[59] CCS also factored in the commodity value of recycled materials with a value of $35/ton.[60] Table XX provides the results of the cost analysis. The analysis assumes that costs begin to be incurred in 2010. The estimated cost savings result in an NPV of -$72 million. Cumulative reductions are almost 13 MMtCO$_2$e, and the estimated cost-effectiveness is -$6/MtCO$_2$e.

Table XX: Cost analysis results for recycling

Year	Tons Recycled	Annual Collection Cost (2006$MM)	Annual Capital Cost (2006$MM)	Annual Recycled Material Revenue (2006$MM)	Landfill Tip Fees Avoided (2006$MM)	Net Policy Cost (Recycling) (2006$MM)	Discounted Costs (MM$)	GHG Reductions (MMt)	Cost Effectiveness ($/Mt)

[55] **Not a MD-specific estimate. Seek additional input from TWG.** T. Brownell, Eureka Recycling, personal communication with S. Roe, CCS, December 17, 2007. This value compares favorably with data provided to the AFW TWG (T. Troolin, St. Louis County) on recycling costs incurred by MN counties.
[56] Population projection for 2020 from the MD Inventory and Forecast.
[57] US Census Bureau. State & County QuickFacts – Maryland. Accessed on January 11, 2008 from: http://quickfacts.census.gov/qfd/states/24000.html.
[58] **Not a MD-specific estimate. Seek additional input from TWG.** Based upon ratio of Capital Cost per household used in Vermont Analysis. VT capital cost a result of Personal Communication with P. Calabrese.
[59] Maryland Department of the Environment. 2006. "Annual Report: Solid Waste Management in Maryland – Calendar Year 2005." September 2006. Accessed on December 20, 2007 from: http://www.mde.state.md.us/assets/document/SW_Managed_in_MD_Report_CY_2005.pdf.
[60] **Not a MD-specific estimate. Seek additional input from TWG.** T. Brownell, Eureka Recycling, personal communication with S. Roe, CCS, December 17, 2007. This value compares to a wide range of weighted commodity value provided by T. Troolin, St. Louis County. The weighted commodity value range is estimated to be about $25 to $70/ton with the higher end representing current values. CCS selected the value of $35/ton as a conservative estimate for this analysis.

Year	Tons Recycled	Annual Collection Cost (2006$MM)	Annual Capital Cost (2006$MM)	Annual Recycled Material Revenue (2006$MM)	Landfill Tip Fees Avoided (2006$MM)	Net Policy Cost (Recycling) (2006$MM)	Discounted Costs (MM$)	GHG Reductions (MMt)	Cost Effectiveness ($/Mt)
2009	-	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	0.00	
2010	113,347	$5.81	$16.51	$3.97	$5.89	$12.45	$11.86	0.20	
2011	234,317	$12.00	$16.51	$8.20	$12.18	$8.12	$7.37	0.39	
2012	363,293	$18.61	$16.51	$12.72	$18.89	$3.51	$3.03	0.59	
2013	500,678	$25.64	$16.51	$17.52	$26.04	-$1.41	-$1.16	0.78	
2014	646,890	$33.13	$16.51	$22.64	$33.64	-$6.64	-$5.20	0.98	
2015	802,369	$41.09	$16.51	$28.08	$41.72	-$12.20	-$9.11	1.18	
2016	912,281	$46.72	$16.51	$31.93	$47.44	-$16.14	-$11.47	1.37	
2017	1,028,678	$52.68	$16.51	$36.00	$53.49	-$20.30	-$13.74	1.56	
2018	1,151,871	$58.99	$16.51	$40.32	$59.90	-$24.71	-$15.93	1.75	
2019	1,282,185	$65.67	$16.51	$44.88	$66.67	-$29.37	-$18.03	1.95	
2020	1,419,960	$72.72	$16.51	$49.70	$73.84	-$34.30	-$20.06	2.13	
						-$121.00	**-$72.44**	**12.9**	**-$5.63**

Composting. The net costs for increased composting in Maryland were estimated by adding the additional costs for collection (same calculation as recycling) with the net costs for composting operations. The net cost for composting operations is the sum of the annualized capital and operating costs of composting, increased collection fees, revenue generated through the sale of compost, the avoided tipping fees for landfilling. Information on the capital and operating costs of composting facilities was received from Cassella Waste Management during the analysis of a similar option in Vermont.[61] These data are summarized in Table XX.

Table XX. Cost information for composting facilities

Annual Volume (tons)	Capital Cost (2007 $,000)	Operating Cost ($/ton)
<1,500	75	25
1,500–10,000	200	50
10,000–30,000	2,000	40
30,000–60,000+	8,000	30

CCS assumed that the composting facilities to be built within the policy period would tend to be from the largest category (achieving the most efficient operating costs) shown in Table XX. The composting volumes in 2015 and 2020 shown in Table XX suggest the need for about 4 large composting operations by 2015 and another 4 large operations by 2020. To annualize the capital costs for these facilities, CCS assumed a 15-year operating life and a 5% interest rate. Other cost assumptions include an assumed landfill tipping fee of $52/ton,[62] an additional

[61] **Not a MD-specific estimate. Seek additional input from TWG.** P. Calabrese, Cassella Waste Management, personal communication with S. Roe, CCS, June 5, 2007.
[62] Maryland Department of the Environment. 2006. "Annual Report: Solid Waste Management in Maryland – Calendar Year 2005." September 2006. Accessed on December 20, 2007 from: http://www.mde.state.md.us/assets/document/SW_Managed_in_MD_Report_CY_2005.pdf.

source-separated organics collection fee of $2.50/household (or $51/ton, as used above in the recycling element), a compost facility tipping fee of $24/ton,[63] and a compost value of $10/ton.[64]

Table 43 presents the results of the cost analysis for composting. GHG reductions were assumed not to begin until 2010, and the cumulative reductions estimated were 0.47 $MMtCO_2e$. An NPV of $91 million was estimated along with a cost effectiveness of $196/Mt.

Table XX: Cost analysis results for composting

Year	Annual Cost O&M (2006$MM)	Capital Cost (2007$MM)	Annualized Capital Cost (2006$MM)	Annual Collection Cost (2006$MM)	Avoided Landfill Tipping Fees (2006$MM)	Value of Composted Material (2006$MM)	Tons of Waste Composted	Total Annual Composting Cost (2006$)	Discounted Costs (2007MM$)	GHG Reductions (MMtCO2e)	Cost Effectiveness ($/Mt)
2009	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	-	$0.00	$0.00	-	
2010	$0.92	$8.00	$0.77	$1.58	$0.87	$0.32	30,811	$2.08	$1.98	0.01	
2011	$1.91	$0.00	$0.77	$3.26	$1.81	$0.67	63,694	$3.47	$3.14	0.01	
2012	$2.96	$8.00	$1.54	$5.06	$2.80	$1.04	98,754	$5.72	$4.94	0.02	
2013	$4.08	$8.00	$2.31	$6.97	$3.86	$1.43	136,099	$8.07	$6.64	0.03	
2014	$5.28	$0.00	$2.31	$9.01	$4.99	$1.84	175,844	$9.76	$7.64	0.04	
2015	$6.54	$8.00	$3.08	$11.17	$6.19	$2.29	218,107	$12.32	$9.19	0.04	
2016	$7.44	$8.00	$3.85	$12.70	$7.04	$2.60	247,985	$14.35	$10.20	0.05	
2017	$8.39	$8.00	$4.62	$14.32	$7.94	$2.93	279,625	$16.46	$11.14	0.06	
2018	$9.39	$0.00	$4.62	$16.04	$8.89	$3.28	313,112	$17.88	$11.53	0.06	
2019	$10.46	$8.00	$5.40	$17.85	$9.89	$3.66	348,535	$20.15	$12.37	0.07	
2020	$11.58	$8.00	$6.17	$19.77	$10.96	$4.05	385,987	$22.51	$13.16	0.08	
									$91.94	**0.47**	**$195.54**

The overall cost analysis – as seen in Table XX – yields a NPV of -$1,154 and a cost effectiveness of -$6, based on the cumulative emission reductions of 187 $MMtCO_2e$.

Table XX: Overall Policy Results – Cost Effectiveness

Year	Net Program Cost Recycling ($MM)	Net Program Cost Composting ($MM)	Net Program Cost Source Reduction ($MM)	Total Net Program Cost ($MM)	Discounted Cost (2006$MM)	Cost Effectiveness ($/MtCO2e)
2009	$0.00	$0.00	$0.00	$0.00	$0.00	
2010	$12.45	$2.08	-$22.44	-$7.92	-$7.54	
2011	$8.12	$3.47	-$52.66	-$41.07	-$37.25	
2012	$3.51	$5.72	-$84.88	-$75.65	-$65.35	
2013	-$1.41	$8.07	-$108.77	-$102.10	-$84.00	

[63] Montgomery County, MD. Department of Environmental Protection. "Composting/Grasscycling Program Summary." Accessed on January 11, 2008 from: http://www.montgomerycountymd.gov/deptmpl.asp?url=/content/dep/composting/summary.asp. [NOTE]: Figures originally presented in 1995$. Converted to 2006$ using conversion tool at http://www.westegg.com/inflation/.
[64] *Ibid.*

Year	Net Program Cost Recycling ($MM)	Net Program Cost Composting ($MM)	Net Program Cost Source Reduction ($MM)	Total Net Program Cost ($MM)	Discounted Cost (2006$MM)	Cost Effectiveness ($/MtCO2e)
2014	-$6.64	$9.76	-$134.16	-$131.04	-$102.67	
2015	-$12.20	$12.32	-$161.13	-$161.02	-$120.15	
2016	-$16.14	$14.35	-$180.54	-$182.33	-$129.58	
2017	-$20.30	$16.46	-$201.07	-$204.91	-$138.69	
2018	-$24.71	$17.88	-$222.77	-$229.60	-$148.00	
2019	-$29.37	$20.15	-$245.70	-$254.92	-$156.50	
2020	-$34.30	$22.51	-$269.91	-$281.71	-$164.71	
					-$1,154.45	**-$6.18**

- **Key Assumptions:** For the MSW management input data to WArm, the key assumption is that none of the goals would be achieved via existing programs in place. To the extent that those programs will achieve or partially achieve the goals of this policy, the GHG reductions estimated would be lower (no additional penetration from the current MDE recycling and composting campaigns has been incorporated into the BAU assumptions for this analysis). Therefore, the most important assumption relates to the assumed BAU projection for solid waste management. This BAU forecast is based on current practices and does not factor in the effects of further gains in recycling or composting rates during the policy period. The BAU assumptions are needed to tie into the assumptions used to develop the GHG forecast for the waste management sector, which does not factor in these changes in waste management practices during the policy period (2008–2020). To the extent that these gains in recycling and composting would occur without this policy, the benefits and costs are overstated.

  The other key assumptions relate to the use of the WArm model in estimating lifecycle GHG benefits and the use of the stated assumptions regarding costs for increased source reduction, recycling, and organics recovery (composting in this example) programs.

  Another important assumption is that under BAU, the waste directed to landfilling would include methane recovery (75% collection efficiency) and utilization. The need for this assumption is partly based on limitations of the WArm model (which doesn't allow for management of landfilled waste into both controlled and uncontrolled landfills), but also based on the overall direction of the policy recommendations of AFW-9.

  Additionally, transportation emissions for WARM are taken as default. This analysis has not considered the impacts of reduced exports as a result of the goals in the Policy Design.

  The cost estimates do not include cost savings that would be achieved through avoiding the need for additional WTE plants.

Quantification of carbon emissions of associated transportation of solid waste may be a useful figure.

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 MWG moves to final agreement at meeting #5 or #6]

Level of Group Support

TBD – [blank until MWG meeting #5]

Barriers to Consensus

TBD – [blank until final vote until final MWG meeting]