Maryland Climate Action Plan

Appendix A

Maryland Executive Order Establishing The Maryland Commission on Climate Change

EXECUTIVE ORDER
01.01.2007.07

Commission on Climate Change

WHEREAS, As reported by the United Nations Intergovernmental Panel on Climate Change (IPCC) in February 2007, there is now near universal scientific consensus that the world climate is changing, with an estimated rise in temperature between 1.98 – 11.52° F and as much as 7 to 23 inches of global sea level rise, over the next century;

WHEREAS, Human activities, including coastal development, the burning of fossil fuels and increasing greenhouse gas emissions are contributing to the causes and consequences of climate change;

WHEREAS, Maryland's people, property, natural resources, and public investments are extremely vulnerable to the ensuing impacts of climate change, including sea level rise, increased storm intensity, extreme droughts and heat waves, and increased wind and rainfall events;

WHEREAS, The effects of climate change already are being detected in Maryland, as historic tide-gauge records show that sea level has risen one-foot over the last century within State waters;

WHEREAS, Based on the current IPCC estimates and the rate of regional land subsidence, Maryland may experience an additional two to three foot sea level rise along its coast by the Year 2099;

WHEREAS, Recent State actions demonstrate Maryland's strong commitment to addressing both the drivers and consequences of climate change:

- Formulation and implementation of a State Sea Level Rise Response Strategy (2000);
- Passage of the Healthy Air Act (2006);
- Development of Maryland Transition Reports which call for State level action to address the drivers and consequences of climate change (2007);
- Passage of the Clean Cars Act (2007); and
- Participation in the Regional Greenhouse Gas Initiative (2007);

WHEREAS, It is imperative that Maryland State Government, as well as local governments, continue to lead by example in the scope and variety of services and activities that government provides and undertakes; and

WHEREAS, More must be done to reduce greenhouse gas emissions and prepare the State of Maryland for the likely physical, environmental, and socio-economic consequences of climate change.

NOW, THEREFORE, I, MARTIN O'MALLEY, GOVERNOR OF THE STATE OF MARYLAND, BY VIRTUE OF THE AUTHORITY VESTED IN ME BY THE CONSTITUTION AND LAWS OF MARYLAND, HEREBY PROCLAIM THE FOLLOWING EXECUTIVE ORDER, EFFECTIVE IMMEDIATELY**:**

A. Established. A Climate Change Commission is hereby established to advise the Governor and General Assembly on matters related to climate change.

B. Tasks. The Commission shall develop a Plan of Action to address the drivers and causes of climate change, to prepare for the likely consequences and impacts of climate change to Maryland, and to establish firm benchmarks and timetables for implementing the Plan of Action.

C. Membership.

(1) The Commission shall consist of up to 21 members, including:

(a) The Secretary of Agriculture, or the Secretary's designee;

(b) The Secretary of Budget and Management, or the Secretary's designee;

(c) The Secretary of Business and Economic Development, or the Secretary's designee;

(d) The State Superintendent of Schools, or the Superintendent's designee:

(e) The Secretary of Natural Resources, or the Secretary's designee;

(f) The Secretary of the Environment,or the Secretary's designee;

(g) The Secretary of Planning, or the Secretary's designee;

(h) The Secretary of Transportation, or the Secretary's designee;

(i) The Director of the Governor's Office of Homeland Security, or the Director's designee;

(j) The Director of the Maryland Energy Administration, or the Director's designee;

(k) The Secretary of Housing and Community Development, or the Secretary's designee;

(l) The Maryland Insurance Commissioner, or the Commissioner's designee;

(m) The Director of the Maryland Emergency Management Agency, or the Director's designee;

(n) The Chairman of the Public Service Commission, or the Chairman's designee; and

(o) The Chancellor of the University System of Maryland, or the Chancellor's designee;

(2) The Speaker of the House of Delegates and the President of the Senate are invited to appoint 3 members, respectively, from the House of Delegates and Senate, to serve as members of the Commission.

D. Chair. The Chair of the Commission shall be designated by the Governor from among the members of the Commission.

E. Staff Coordination. The Department of Natural Resources and Department of the Environment shall jointly staff the Commission in coordination with other State agencies as directed by the Chair.

F. Working Groups. The Commission shall be supported by Working Groups, to be established by the Chair, as follows:

(1) Scientific and Technical Working Group.

(a) Tasks. The Working Group shall develop a Comprehensive Climate Change Impact Assessment. The Assessment should:

(i) Advise the Commission, as well as other Working Groups, on the scientific and technical aspects of climate change;

(ii) Inventory Maryland's greenhouse gas emission sources and sinks;

(iii) Calculate Maryland's "carbon footprint" to measure the impact of human activities on the environment based on the State's greenhouse gas production;

(iv) Investigate climate change dynamics, including current and future climate models and forecasts; and

(v) Evaluate the likely consequences of climate change to Maryland's agricultural industry, forestry resources, fisheries resources, fresh water supply, aquatic and terrestrial ecosystems, and human health.

(b) Chair. The Scientific and Technical Working Group will be chaired and staffed jointly by the University System of Maryland, the Maryland Department of the Environment and the Department of Natural Resources.

(2) Greenhouse Gas and Carbon Mitigation Working Group.

(a) Tasks. The Working Group shall develop a Comprehensive Greenhouse Gas and Carbon Footprint Reduction Strategy. The Strategy should:

(i) Evaluate and recommend goals that include but not be limited to the reduction of Maryland's greenhouse gas emissions to 1990 levels by 2020 and 80% of 2006 levels by 2050;

(ii) Recommend short and long-term goals and strategies that include both energy and non-energy related measures to mitigate greenhouse gases and offset carbon emissions; and

(iii) Provide a detailed implementation timetable, with benchmarks, for each recommendation and strategy.

(b) Chair. The Greenhouse Gas and Carbon Mitigation Working Group shall be chaired and staffed jointly by the Department of the Environment and the Maryland Energy Administration.

(3) Adaptation and Response Working Group.

(a) Tasks. The Working Group shall develop a Comprehensive Strategy for Reducing Maryland's Climate Change Vulnerability. The Strategy should:

(i) Recommend strategies for reducing the vulnerability of the State's coastal, natural and cultural resources and communities to the impacts of climate change, with an initial focus on sea level rise and coastal hazards (e.g., shore erosion, coastal flooding);

(ii) Establish strategies to address short and long-term adaptation measures, planning and policy integration, education and outreach, performance measurement, and as necessary, new legislation and/or modifications that will strengthen and enhance the ability of the State and its local jurisdictions to plan for and adapt to the impacts of climate change;

(iii) Work with local governments to identify their capacity to plan for and adapt to sea level rise;

(iv) Develop appropriate guidance to assist local governments with identifying specific measures (e.g., local land use regulations and ordinances) to adapt to sea level rise and increasing coastal hazards; and

(v) In consultation with the Scientific and Technical Working Group, propose a timetable for the development of adaptation strategies to reduce climate change vulnerability among affected sectors, such as agriculture, forestry, water resources, aquatic and terrestrial ecosystems, and human health.

(b) Chair. The Adaptation and Response Working Group shall be chaired and staffed jointly by the Department of Natural Resources and the Department of Planning.

(4) Additional Working Groups and/or Subcommittees to Working Groups may be created, as necessary, to accomplish the Commission mandate and Working Group Tasks.

(5) Appointments.

(a) The Chair of the Commission shall appoint Working Group and Subcommittee members who broadly represent both public and private interests in climate change, including but not limited to: Other levels of government, academic institutions, renewable and traditional energy providers, environmental organizations, labor organizations, and business interests, including the insurance industry.

(b) Working Group and Subcommittee members shall serve at the pleasure of the Commission.

(c) Working Group and Subcommittee members may not receive compensation for service.

G. Milestones.

(1) Within 60 days of the effective date of this Executive Order, the Commission shall be convened and Working Group members appointed.

(2) Within 90 days of the effective date of this Executive Order, Working Groups shall meet and establish individual work plans.

(3) Within one year of the effective date of this Executive Order, the Commission shall present to the Governor and General Assembly the Plan of Action, including the Comprehensive Climate Change Impact Assessment, the Comprehensive Greenhouse Gas and Carbon Footprint Reduction Strategy, and the Comprehensive Strategy for Reducing Maryland's Climate Change Vulnerability.

H. Reporting. The Commission shall report to the Governor and General Assembly on or before November 1 of each year including November 1, 2007 on the Plan of Action, including an update on development of the Plan of Action, implementation timetables and benchmarks, and preliminary recommendations, including draft legislation , if any, for consideration by the General Assembly.

GIVEN Under My Hand and the Great Seal of the State of Maryland, in the City of Annapolis, this 20th Day of April, 2007.

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Martin O'Malley
Governor

ATTEST:

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Dennis Schnepfe
Interim Secretary of State

Maryland Climate Action Plan

Appendix B

Membership Lists

Maryland Commission on Climate Change
Working Groups
Technical Work Groups

Maryland Commission on Climate Change

Shari T. Wilson, Chair, Secretary Department of the Environment
Delegate Kumar P. Barve, Maryland General Assembly
Delegate Virginia P. Clagett, Maryland General Assembly
Alvin C. Collins, Secretary Department of General Services
John Droneburg, Director Maryland Emergency Management Agency
David Edgerley, Secretary Department of Business and Economic Development
T. Eloise Foster, Secretary Department of Budget and Management
Senator Brian E. Frosh, Maryland General Assembly
Nancy S. Grasmick, Superintendant of Schools Department of Education
John R. Griffin, Secretary Department of Natural Resources
Richard Eberhart Hall, Secretary Department of Planning
William E. Kirwan, Chancellor University System of Maryland
Steven B. Larsen, Chairman Public Service Commission
Andrew Lauland, Advisor Governor's Office on Homeland Security
Senator Paul G. Pinsky, Maryland General Assembly
Senator E. J. Pipkin, Maryland General Assembly
John D. Porcari, Secretary Department of Transportation
Roger L. Richardson, Secretary Department of Agriculture
Delegate David D. Rudolph, Maryland General Assembly
Raymond A. Skinner, Secretary Department of Housing and Community Development
Ralph S. Tyler, Commissioner Maryland Insurance Administration
Malcolm D. Woolf, Director Maryland Energy Administration

Adaptation & Response Working Group

John Griffin, Chair, Department of Natural Resources
Richard Hall and Don Halligan, Co-Chairs, Department of Planning
Zoë Johnson, Staff Coordinator, Department of Natural Resources
Jason Dubow, Staff Coordinator, Department of Planning

Jenn Aiosa, Chesapeake Bay Foundation
Rodney Banks, Dorchester County
Ron Bowen, Anne Arundel County
Russell Brinsfield, University of Maryland, Harry R. Hughes Center for Agro-Ecology
Sherwood Thomas Brooks, Maryland Association of Realtors
Carl Bruch, Environmental Law Institute
David Burke, David Burke & Associates
Ron Cascio, Chestnut Creek
Sally Clagget, U.S. Forest Service, Chesapeake Bay Program
Phillip Conner, Marine Trades Association
Peter Conrad, Baltimore City
Gilbert W. Dissen, Dissen & Juhn Corporation
Ira Feldman, Greentrack
John W. Frece, University of Maryland, Center for Smart Growth
Bill Giese, U.S. Fish & Wildlife Service, Blackwater Wildlife Refuge
Julie Gorte, Pax World
Lara Hansen, World Wildlife Fund
Lynn Heller, Citizen
Jason Holstine, Amicas
Jesse Houston, Ocean City
Anthony Janetos, University of Maryland, Joint Global Change Institute
Joan Kean, Somerset County
Dennis King, University of Maryland, Chesapeake Biological Laboratory
John Kostyack, National Wildlife Federation
Peter Lefkin, Allianz of North America Corp.
Joseph Maheady, U.S. Green Building Council
Karen McJunkin, Elm Street Development
William Miles, Maryland Forestry Association
Mayor Ellen Moyer, City of Annapolis
Joy Oakes, National Parks Conservation Association
Robert Pace, U.S. Army Corps of Engineers
Dru Schmidt-Perkins, 1000 Friends of Maryland
Court Stevenson, University of Maryland, Horn Point Laboratory
Sue Veith, St. Mary's County

Technical Work Groups of the Adaptation & Response Working Group

Existing Built Environment & Infrastructure

Sherwood T. "Duke" Brooks
Carl Bruch
Phillip Conner
Peter Conrad
Gilbert W. Dissen
Jesse Houston
Karen McJunkin
Robert Pace

Human Health, Safety & Welfare

Rodney Banks
Ron Bowen
Lynn Heller
Joan Kean
Peter Lefkin
Ira Feldman
Clifford Mitchell
Cathy O'Neill

Future Built Environment & Infrastructure

Ron Bowen
Ron Cascio
Gilbert W. Dissen
John W. Frece
Julie Gorte
Jason Holstine
Joseph Maheady
Dru Schmidt-Perkins
Sue Veith

Resources & Resource-Based Industries

Jenn Aiosa
Russ Brinsfield
Steve Bunker
David Burke
Sally Claggett
Jason Dubow
William (Bill) Giese, Jr.
Lara Hansen
Dennis King
John Kostyack
William (Bill) Miles
Ellen Moyer
Joy Oakes
Court Stevenson

Greenhouse Gas & Carbon Mitigation Working Group

Tad Aburn, Chair, Department of the Environment
Malcolm Woolf , Co-Chair, Maryland Energy Administration

Uri Avin, Parsons Brinkerhoff
Paul Chan, Citizen
William Chandler, Transition Energy
Drew Cobbs, Maryland Petroleum Council
Richard D'Amato, Synergics, Inc.
Robert Driscoll, Mirant
Joel Dunn, The Conservation Fund
Nancy Floreen, Montgomery County Council
Jonathan Gibralter, Frostburg State University
Ed Guigliano, AES Warrior Run
Michelle Harris Bondima, Baltimore City Community College
Brad Heavner, Environment Maryland
Frank Heintz, Citizen
William Hellman, Rummel, Klepper & Kahl
Peggy Horst, W.L. Gore
Debra Jacobson, DJ Consulting
Mark Joseph, Yellow Transportation
George Kelly, Environmental Banc & Exchange
Thomas Koch, Curtis Engine & Equipment
Michael Mallinoff, City of Annapolis
Elizabeth Martin-Perera, Natural Resources Defense Council
Dr. Cindy Parker, Johns Hopkins Bloomberg School of Public Health
John Quinn, Constellation Energy
Michael Replogle, Environmental Defense
Matthias Ruth, University of Maryland, Center for Integrative Environmental Research
Scot Spencer, Annie E. Casey Foundation
John Szallay, BP Solar
Lise Van Susteren, The Climate Project

Technical Work Groups of the Greenhouse Gas & Carbon Mitigation Working Group

Transportation & Land Use
Regina Aris
Uri Avin
Drew Cobbs
Nancy Floreen
Jonathan Gibralter
Pete Gutwald
William Hellman
Pam Parker
Michael Replogle
Lise Van Susteren

Agriculture, Forestry& Waste Management
Gary Allen
Val Connelly
Joel Dunn
Bob Ensor
George Kelly
Laura Miller
Cindy Parker
James Remuzzi
Eric Sprague
Elmer Weibley

Cross-Cutting Issues
Misty Allen
Paul Chan
Robert Driscoll
Joel Dunn
Frank Heintz
Julian Levy
Michael Mallinoff
Elizabeth Martin-Perera
Adrienne Ottaviani
Cindy Parker
John Quinn
Scot Spencer

Energy Supply
Misty Allen
Randy Cain
Eric Coffman
Bill Cunningham
Richard D'Amato
Robert Driscoll
Ed Giugliano
Brad Heavner
Frank Heintz
Debra Jacobson
Thomas Koch
Elizabeth Martin-Perera
Adrienne Ottaviani
Michael Replogle
Lise Van Susteren

Residential, Commercial & Industrial Use
Paul Chan
William Chandler
Todd Chason
Brad Heavner
Michelle Harris Bondima
John Kumm
Julian Levy
William Livingston
Michael Mallinoff
Matthias Ruth
Scott Sklar

Scientific & Technical Working Group

Donald F. Boesch, Chair, University of Maryland Center for Environmental Science
Frank W. Dawson, Co-Chair, Maryland Department of Natural Resources
Robert M. Summers, Co-Chair, Maryland Department of the Environment

William C. Boicourt, University of Maryland Center for Environmental Science
Antonio J. Busalacchi, University of Maryland, College Park
Donald R. Cahoon, U.S. Geological Survey
Frank J. Coale, University of Maryland, College Park
Victoria J. Coles, University of Maryland Center for Environmental Science
Russell R. Dickerson, University of Maryland, College Park
William M. Eichbaum, World Wildlife Fund
Brian D. Fath, Towson University
Raymond M. Hoff, University of Maryland, Baltimore County
David G. Kimmel, University of Maryland Center for Environmental Science
Curtis E. Larsen, Lusby, Maryland (U.S. Geological Survey, retired)
Andrew J. Miller, University of Maryland, Baltimore County
Margaret A. Palmer, University of Maryland Center for Environmental Science
Louis F. Pitelka, University of Maryland Center for Environmental Science
Steven D. Prince, University of Maryland, College Park
Brian S. Schwartz, The Johns Hopkins University
David H. Secor, University of Maryland Center for Environmental Science
Timothy Warman, National Wildlife Federation
Claire Welty, University of Maryland, Baltimore County

Maryland Climate Action Plan

Appendix C
Inventory & Forecast

FINAL Maryland Greenhouse Gas Inventory and Reference Case Projections 1990-2020

Center for Climate Strategies June 2008

Principal Authors: Randy Strait, Maureen Mullen, Bill Dougherty, Andy Bollman, Luana Williams

CENTER FOR CLIMATE STRATEGIES

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Executive Summary

The Center for Climate Strategies (CCS) prepared this report for the Maryland Department of the Environment (MDE). The report presents an assessment of the State's greenhouse gas (GHG) emissions from 1990 to 2020. The preliminary inventory and forecast emission estimates served as a starting point to assist the State, as well as the Maryland Greenhouse Gas & Carbon Mitigation Working Group, with an initial comprehensive understanding of Maryland's current and possible future GHG emissions, and thereby informed the identification and analysis of policy options for mitigating GHG emissions.[1] The Mitigation Working Group and Technical Working Groups have reviewed, discussed, and evaluated the draft inventory and methodologies as well as alternative data and approaches for improving the draft GHG inventory and forecast. The inventory and forecast, as well as this report, have been revised to address the comments provided and approved by the Mitigation Working Group.

Maryland's anthropogenic GHG emissions and anthropogenic sinks (carbon storage) were estimated for the period from 1990 to 2020. Historical GHG emissions estimates (1990 through 2005)[2] were developed using a set of generally accepted principles and guidelines for State GHG emissions, relying to the extent possible on Maryland-specific data and inputs. The reference case projections (2006-2020) are based on a compilation of various existing Maryland projections of electricity generation, fuel use, and other GHG-emitting activities, along with a set of simple, transparent assumptions described in the appendices of this report.

The inventory and projections cover the six types of gases included in the US Greenhouse Gas Inventory: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF_6). Emissions of these GHGs are presented using a common metric, CO_2 equivalence (CO_2e), which indicates the relative contribution of each gas, per unit mass, to global average radiative forcing on a global warming potential- (GWP-) weighted basis.[3]

Table ES-1 provides a summary of historical and reference case projection GHG emissions for Maryland for the years 1990, 2000, 2005, 2010, and 2020. Activities in Maryland accounted for approximately 109 million metric tons (MMt) of *gross*[4] CO_2e emissions (consumption basis) in 2005, an amount equal to about 1.5% of total US gross GHG.[5] Maryland's gross GHG emissions

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[1] Draft Maryland Greenhouse Gas Inventory and Reference Case Projections 1990–2020, prepared by the Center for Climate Strategies for the Maryland Department of the Environment, January 2008.

[2] The last year of available historical data varies by sector; ranging from 2000 to 2005.

[3] Changes in the atmospheric concentrations of GHGs can alter the balance of energy transfers between the atmosphere, space, land, and the oceans. A gauge of these changes is called radiative forcing, which is a simple measure of changes in the energy available to the Earth–atmosphere system (IPCC, 2001). Holding everything else constant, increases in GHG concentrations in the atmosphere will produce positive radiative forcing (i.e., a net increase in the absorption of energy by the Earth). See: Boucher, O., et al. "Radiative Forcing of Climate Change." Chapter 6 in *Climate Change 2001: The Scientific Basis*. Contribution of Working Group 1 of the Intergovernmental Panel on Climate Change Cambridge University Press. Cambridge, United Kingdom. Available at: http://www.grida.no/climate/ipcc_tar/wg1/212.htm.

[4] Excluding GHG emissions removed due to forestry and other land uses.

[5] The national emissions used for these comparisons based on 2005 emissions from *Inventory of US Greenhouse Gas Emissions and Sinks: 1990–2006*, April 15, 2008, US EPA # 430-R-08-005, http://www.epa.gov/climatechange/emissions/usinventoryreport.html.

are rising at a slightly faster rate than those of the nation as a whole (gross emissions exclude carbon sinks, such as forests). Maryland's gross GHG emissions increased by about 18% from 1990 to 2005, while national emissions rose by 16% from 1990 to 2005. The growth in Maryland's emissions from 1990 to 2005 is primarily associated with the transportation and electricity consumption sectors.

Estimates of carbon sinks within Maryland's forests, including urban forests and land use changes, have also been included in this report. The current estimates indicate that about 12 $MMtCO_2e$ was stored in Maryland forest biomass and agricultural soils in 2005. This leads to *net* emissions of 98 $MMtCO_2e$ in Maryland in 2005.

Figure ES-1 illustrates the State's emissions per capita and per unit of economic output. On a gross emissions per capita basis, Maryland residents emitted about 19.3 metric tons (t) of gross CO_2e in 1990, lower than the national average of 24.6 tCO_2e in 1990. Per capita emissions in Maryland increased to 19.7 tCO_2e/yr by 2005, while the per capita emissions for the US have decreased slightly to 24.0 tCO_2e/yr by 2005. Like the nation as a whole, Maryland's economic growth exceeded gross emissions growth throughout the 1990-2005 period (leading to declining estimates of GHG emissions per unit of state product). From 1990 to 2005, gross emissions per unit of gross product dropped by 27% nationally, and by 21% in Maryland.[6]

There are three principal sources of GHG emission in Maryland: electricity consumption; transportation; and residential, commercial, and industrial (RCI) fuel use. Electricity consumption accounted for 42% of gross GHG emissions in 2005. Transportation accounted for 30% of Maryland's gross GHG emissions in 2005, while RCI fuel use accounted for 18% of Maryland's 2005 gross GHG emissions.

As illustrated in Figure ES-2 and shown numerically in Table ES-1, under the reference case projections, Maryland's gross GHG emissions continue to grow, and are projected to climb to about 132 $MMtCO_2e$ by 2020, reaching 42% above 1990 levels.[7] As shown in Figure ES-3, the electricity consumption sector is projected to be the largest contributor to future emissions growth in Maryland, followed by the transportation sector and substitutes for ozone-depleting substances (ODS).

Some data gaps exist in this analysis, particularly for the reference case projections. Key refinements include review and revision of key emissions drivers that will be major determinants of Maryland's future GHG emissions (such as the growth rate assumptions for electricity generation and consumption, transportation fuel use, and RCI fuel use). Appendices A through H provide the detailed methods, data sources, and assumptions for each GHG sector. Also included are descriptions of significant uncertainties in emission estimates or methods and suggested next steps for refinement of the inventory. Appendix I provides background information on GHGs and climate-forcing aerosols.

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[6] Based on real gross domestic product (millions of chained 2000 dollars) that excludes the effects of inflation, available from the US Bureau of Economic Analysis (http://www.bea.gov/regional/gsp/). The national emissions used for these comparisons are based on 2005 emissions from the 2008 version of EPA's GHG inventory report (http://www.epa.gov/climatechange/emissions/usinventoryreport.html).

[7] Note that electricity sector emission reductions attributable to the Regional Greenhouse Gas Initiative (RGGI) are not included in the reference case emissions inventory. Reductions from RGGI are illustrated in Appendix A.

Table ES-1. Maryland Historical and Reference Case GHG Emissions, by Sector[a]

$MMtCO_2e$	1990	2000	2005	2010	2020	Explanatory Notes for Projections
Energy Use (CO_2, CH_4, N_2O)	**84.9**	**93.6**	**99.5**	**102.6**	**117.6**	
Electricity Use (Consumption)[b]	**38.6**	**43.6**	**45.9**	**46.5**	**54.8**	
Electricity Production (in-state)	29.8	35.1	34.0	34.3	39.6	*See electric sector assumptions*
Coal	23.9	30.5	28.8	30.3	35.0	*in appendix A.*
Natural Gas	1.60	1.98	1.52	1.50	1.95	
Oil	4.22	2.42	3.52	2.19	2.35	
Wood	0.003	0.003	0.004	0.009	0.011	
MSW/LFG	0.03	0.21	0.19	0.20	0.22	
Net Imported Electricity	8.83	8.55	11.82	12.27	15.25	
Residential/Commercial/Industrial (RCI) Fuel Use	**21.1**	**19.1**	**20.0**	**20.2**	**20.7**	
Coal	5.54	2.14	3.21	3.23	3.21	Based on US DOE regional projections
Natural Gas	8.25	9.80	9.94	10.4	11.3	Based on US DOE regional projections
Petroleum	7.27	7.04	6.79	6.43	6.16	Based on US DOE regional projections
Wood	0.08	0.10	0.08	0.08	0.07	Based on US DOE regional projections
Transportation	**24.2**	**29.9**	**32.5**	**34.8**	**40.9**	
Onroad Gasoline	17.9	21.6	23.9	25.3	28.8	Based on MDE VMT projections.
Onroad Diesel	2.91	5.09	5.89	6.83	9.18	Based on MDE VMT projections.
Marine Vessels	1.36	1.29	1.18	1.15	1.30	
Rail, Natural Gas, and LPG	0.53	0.22	0.20	0.22	0.25	Based on US DOE regional projections.
Jet Fuel and Aviation Gasoline	1.49	1.68	1.31	1.32	1.42	Based on FAA operations projections.
Fossil Fuel Industry	**0.97**	**0.99**	**1.08**	**1.12**	**1.11**	
Natural Gas Industry	0.76	0.85	0.91	0.91	0.90	Based on historical growth and AEO2006 regional natural gas consumption
Coal Mining	0.21	0.13	0.17	0.21	0.22	Based on AEO2006 coal production growth rates for Northern Appalachia region
Industrial Processes	**2.58**	**3.78**	**4.90**	**6.17**	**8.70**	
Cement Manufacture	0.86	0.86	1.27	1.45	1.82	15-year historical trend in clinker production
Limestone and Dolomite	0.09	0.09	0.11	0.11	0.12	15-year historical trend in consumption
Soda Ash	0.05	0.05	0.05	0.05	0.05	15-year historical trend in consumption
Iron and Steel	0.83	0.75	0.60	0.56	0.50	1997-2005 historical trend in production
ODS Substitutes	0.01	1.53	2.31	3.44	5.63	National emissions projections (US EPA)
Electricity Transmission and Dist.	0.50	0.27	0.25	0.23	0.21	National emissions projections (US EPA)
Semiconductor Manufacturing	0.003	0.009	0.007	0.007	0.005	National emissions projections (US EPA)
Aluminum Production	0.25	0.23	0.30	0.33	0.37	15-year historical trend in production
Agriculture	**2.11**	**2.31**	**1.80**	**1.93**	**1.87**	
Enteric Fermentation	0.47	0.38	0.35	0.33	0.33	Based on projected livestock population
Manure Management	0.34	0.33	0.30	0.32	0.32	Based on projected livestock population
Agricultural Soils	1.29	1.59	1.14	1.28	1.22	Based on 1990-2005 emissions growth
Agricultural Burning	0.01	0.01	0.01	0.01	0.01	Based on 1990-2005 emissions growth
Waste Management	**2.86**	**3.27**	**3.26**	**3.30**	**3.40**	
Waste Combustion	0.00	0.00	0.00	0.00	0.00	Emissions included in the electric sector

	Landfills	2.24	2.57	2.52	2.52	2.52	Based on 1995-2005 emissions growth.
	Wastewater Management	0.58	0.67	0.70	0.75	0.85	Based on 1995-2005 emissions growth.
	Residential Open Burning	0.03	0.03	0.03	0.03	0.03	Based on 2000 data with no growth.
Gross Emissions (Consumption Basis, Excludes Sinks)		**92.4**	**103.0**	**109.4**	**114.0**	**131.5**	
	increase relative to 1990		*11%*	*18%*	*23%*	*42%*	
Emissions Sinks		**-7.9**	**-11.5**	**-11.7**	**-11.9**	**-12.3**	
	Forested Landscape	-2.08	-8.89	-8.89	-8.89	-8.89	Based on estimates from the USFS
	Urban Forestry and Land Use	-5.69	-2.42	-2.62	-2.86	-3.27	
	Agricultural Soils (Cultivation Practices)	-0.15	-0.15	-0.15	-0.15	-0.15	Historical and projected emissions held constant at 1997 levels
Net Emissions (Consumptions Basis) (Including forestry, land use, and ag sinks)		**84.5**	**91.5**	**97.8**	**102.1**	**119.2**	
	increase relative to 1990		*8%*	*16%*	*21%*	*41%*	

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

[b] Note that electricity sector emission reductions attributable to the Regional Greenhouse Gas Initiative (RGGI) are not included in the reference case emissions inventory. Reductions from RGGI are illustrated in Appendix A.

Figure ES-1. Maryland and US Gross GHG Emissions, Per Capita and Per Unit Gross Product

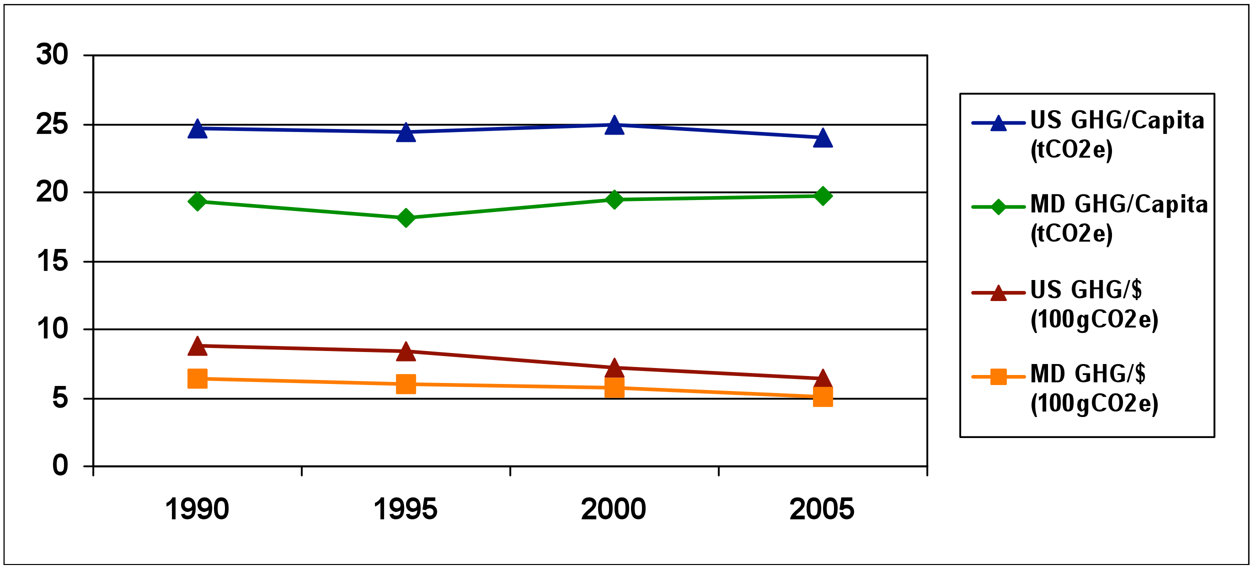
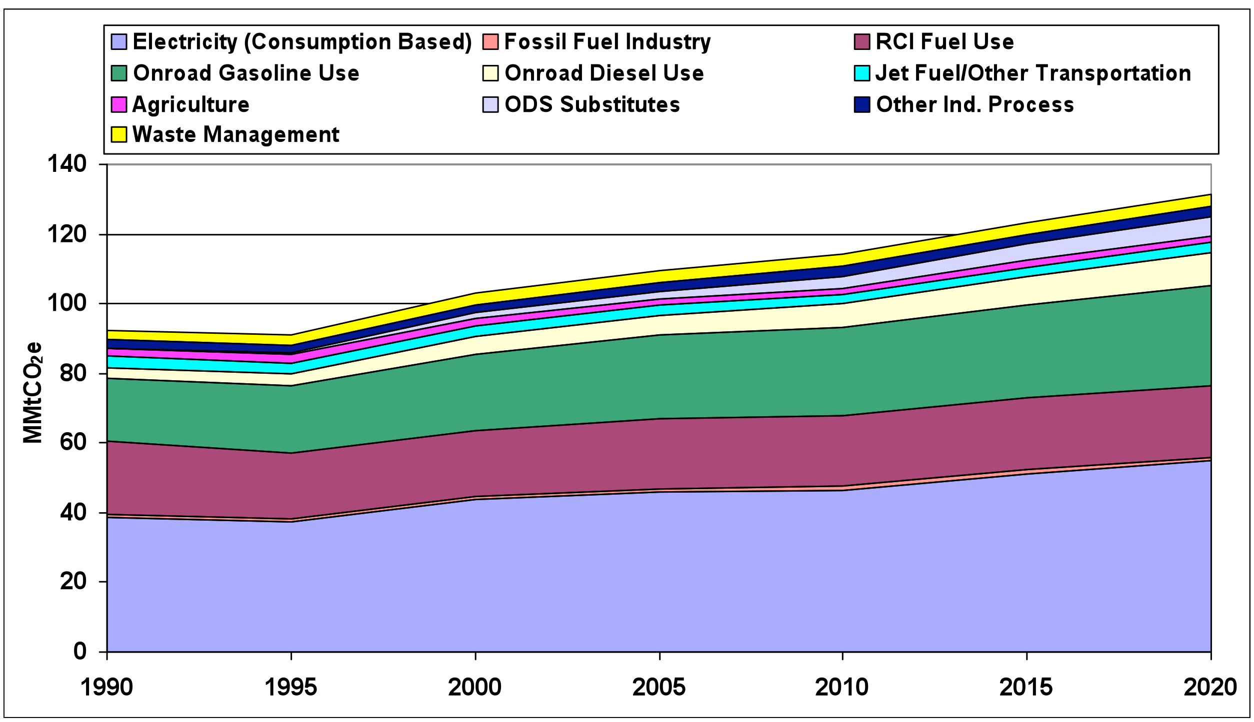
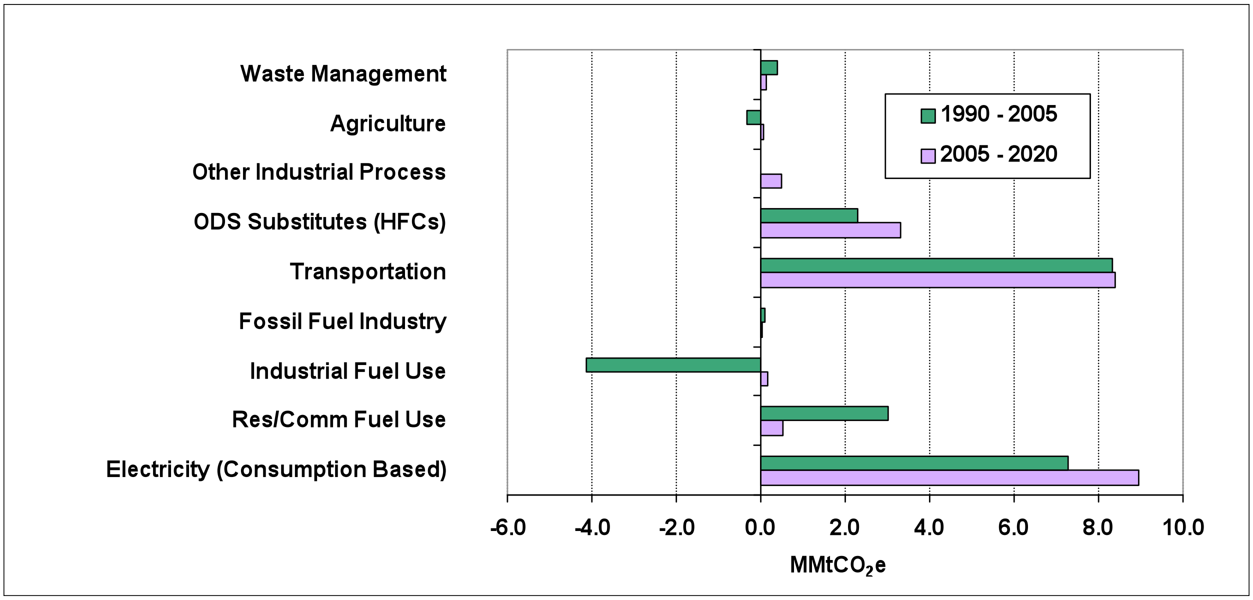


Figure ES-2. Maryland Gross GHG Emissions by Sector, 1990-2020: Historical and Projected



RCI – direct fuel use in residential, commercial, and industrial sectors. ODS – ozone depleting substance.

Figure ES-3. Sector Contributions to Gross GHG Emissions Growth in Maryland, 1990-2020: Reference Case Projections



Res/Comm – direct fuel use in residential and commercial sectors. ODS – ozone depleting substance. HFCs – hydrofluorocarbons. Emissions associated with other industrial processes include all of the industries identified in Appendix D except emissions associated with ODS substitutes which are shown separately in this graph because of high expected growth in emissions for ODS substitutes.

Table of Contents

Acronyms and Key Terms

AEO2006 – EIA's Annual Energy Outlook 2006

AEO2007 – EIA's Annual Energy Outlook 2007

BOD – Biochemical Oxygen Demand

Btu – British Thermal Unit

C – Carbon*

$CaCO_3$ – Calcium Carbonate

CCS – Center for Climate Strategies

CEC – Commission for Environmental Cooperation in North America

CFCs – Chlorofluorocarbons*

CH_4 – Methane*

CO – Carbon Monoxide*

CO_2 – Carbon Dioxide*

CO_2e – Carbon Dioxide Equivalent*

CRP – Federal Conservation Reserve Program

DOE – Department of Energy

DOT – Department of Transportation

EEZ – Exclusive Economic Zone

EIA – US DOE Energy Information Administration

EIIP – Emission Inventory Improvement Program

FAA – Federal Aviation Administration

FAPRI – Food and Agricultural Policy Research Institute

FERC – Federal Energy Regulatory Commission

FHWA – Federal Highway Administration

FIA – Forest Inventory Analysis

Gg – Gigagrams

GHG – Greenhouse Gas*

GWh – Gigawatt-hour

GWP – Global Warming Potential*

H_2O – Water Vapor*

HBFCs – Hydrobromofluorocarbons*

HC – Hydrocarbon

HCFCs – Hydrochlorofluorocarbons*

HFCs – Hydrofluorocarbons*

HWP – Harvested Wood Products

IPCC – Intergovernmental Panel on Climate Change*

kg – Kilogram

km^2 – Square Kilometers

kWh – Kilowatt-hour

lb – Pound

LF – Landfill

LFG – Landfill Gas

LFGTE – Landfill Gas Collection System and Landfill-Gas-to-Energy

LNG – Liquefied Natural Gas

LPG – Liquefied Petroleum Gas

MAAC – Mid-Atlantic Area Council

MANE-VU – Mid-Atlantic/Northeast Visibility Union

MDDNR – Maryland Department of Natural Resources

MDE – Maryland Department of the Environment

Mg – Megagram

MMBtu – Million British Thermal Units

MMt – Million Metric Tons

MMtC – Million Metric Tons Carbon

$MMtCO_2e$ – Million Metric tons Carbon Dioxide Equivalent

MSW – Municipal Solid Waste

Mt – Metric ton (equivalent to 1.102 short tons)

MWh – Megawatt-hour

N_2O – Nitrous Oxide*

NASS – National Agriculture Statistical Service

NEI – National Emissions Inventory

NEMS – National Energy Modeling System

NF – National Forest

NMVOCs – Nonmethane Volatile Organic Compound*

NO_2 – Nitrogen Dioxide*

NO_x – Nitrogen Oxides*

O_3 – Ozone*

ODS – Ozone-Depleting Substance*

OH – Hydroxyl Radical*

OPS – Office of Pipeline Safety

PFCs – Perfluorocarbons*

ppb – Parts per Billion

ppm – Parts per Million

ppt – Parts per Trillion

ppmv – Parts per Million by Volume

RCI – Residential, Commercial, and Industrial

RGGI – Regional Greenhouse Gas Initiative

RPS – Renewable Portfolio Standard

SAR – Second Assessment Report*

SED – State Energy Data

SF_6 – Sulfur Hexafluoride*

Sinks – Removals of carbon from the atmosphere, with the carbon stored in forests, soils, landfills, wood structures, or other biomass-related products.

SIT – State Greenhouse Gas Inventory Tool

SO_2 – Sulfur Dioxide*

t – Metric Ton

T&D – Transmission and Distribution

TAR – Third Assessment Report*

TOG – Total Organic Gas

TWh – Terawatt-hour

UNFCCC – United Nations Framework Convention on Climate Change

US – United States

US DOE – United States Department of Energy

US EPA – United States Environmental Protection Agency

USDA – United States Department of Agriculture

USFS – United States Forest Service

USGS – United States Geological Survey

VMT – Vehicle Mile Traveled

VOCs – Volatile Organic Compound*

WW – Wastewater
yr – Year

* – See Appendix I for more information.

Acknowledgements

We appreciate all of the time and assistance provided by numerous contacts throughout Maryland, as well as in neighboring States, and at federal agencies. Thanks go to in particular the staff at several Maryland State Agencies for their inputs, and in particular to Tad Aburn, Brian Hug, Roger Thunell, Mohamed Khan, and Walter Simms of the Maryland Department of the Environment who provided key guidance for and review of this analytical effort.

The authors would also like to express their appreciation to Katie Bickel, Steve Roe, Katie Pasko, and Jim Wilson of the Center for Climate Strategies (CCS) who provided valuable review comments during development of this report. Thanks also to Michael Gillenwater for directing preparation of Appendix I.

Summary of Findings

Introduction

The Center for Climate Strategies (CCS) prepared this report for the Maryland Department of the Environment (MDE). The report presents an assessment of the State's greenhouse gas (GHG) emissions from 1990 to 2020. The preliminary inventory and forecast emission estimates served as a starting point to assist the State, as well as the Maryland Greenhouse Gas & Carbon Mitigation Working Group, with an initial comprehensive understanding of Maryland's current and possible future GHG emissions, and thereby informed the identification and analysis of policy options for mitigating GHG emissions.[8] The inventory and forecast, as well as this report, have been revised to address the comments provided and approved by the Mitigation Working Group.

Maryland's anthropogenic GHG emissions and anthropogenic sinks (carbon storage) were estimated for the period from 1990 to 2020. Historical GHG emission estimates (1990 through 2005)[9] were developed using a set of generally accepted principles and guidelines for State GHG emissions inventories, as described in the "Approach" section below, relying to the extent possible on Maryland-specific data and inputs. The reference case projections (2006-2020) are based on a compilation of various existing projections of electricity generation, fuel use, and other GHG-emitting activities, along with a set of simple, transparent assumptions described in the appendices of this report.

This report covers the six gases included in the US Greenhouse Gas Inventory: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF_6). Emissions of these GHGs are presented using a common metric, CO_2 equivalence (CO_2e), which indicates the relative contribution of each gas to global average radiative forcing on a Global Warming Potential- (GWP) weighted basis.[10]

It is important to note that these emissions estimates reflect the *GHG emissions associated with the electricity sources used to meet Maryland's demands,* corresponding to a consumption-based approach to emissions accounting (see "Approach" section below). Another way to look at electricity emissions is to consider the *GHG emissions produced by electricity generation facilities in the State.* This report covers both methods of accounting for emissions, but for consistency, all total results are reported as *consumption-based.*

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[8] Draft Maryland Greenhouse Gas Inventory and Reference Case Projections 1990–2020, prepared by the Center for Climate Strategies for the Maryland Department of the Environment, January 2008.

[9] The last year of available historical data varies by sector; ranging from 2000 to 2005.

[10] Changes in the atmospheric concentrations of GHGs can alter the balance of energy transfers between the atmosphere, space, land, and the oceans. A gauge of these changes is called radiative forcing, which is a simple measure of changes in the energy available to the Earth–atmosphere system (IPCC, 2001). Holding everything else constant, increases in GHG concentrations in the atmosphere will produce positive radiative forcing (i.e., a net increase in the absorption of energy by the Earth). See: Boucher, O., et al. "Radiative Forcing of Climate Change." Chapter 6 in *Climate Change 2001: The Scientific Basis*. Contribution of Working Group 1 of the Intergovernmental Panel on Climate Change Cambridge University Press. Cambridge, United Kingdom. Available at: http://www.grida.no/climate/ipcc_tar/wg1/212.htm.

Maryland Greenhouse Gas Emissions: Sources and Trends

Table 1 provides a summary of GHG emissions estimated for Maryland by sector for the years 1990, 2000, 2005, 2010, and 2020. Details on the methods and data sources used to construct these estimates are provided in the appendices to this report**.** In the sections below, we discuss GHG emission sources (positive, or *gross*, emissions) and sinks (negative emissions) separately in order to identify trends, projections, and uncertainties clearly for each.

This next section of the report provides a summary of the historical emissions (1990 through 2005) followed by a summary of the reference-case projection-year emissions (2006 through 2020) and key uncertainties. We also provide an overview of the general methodology, principles, and guidelines followed for preparing the inventories. Appendices A through H provide the detailed methods, data sources, and assumptions for each GHG sector. Appendix I provides background information on GHGs and climate-forcing aerosols.

Table 1. Maryland Historical and Reference Case GHG Emissions, by Sector[a]

$MMtCO_2e$	1990	2000	2005	2010	2020	Explanatory Notes for Projections
Energy Use (CO_2, CH_4, N_2O)	**84.9**	**93.6**	**99.5**	**102.6**	**117.6**	
Electricity Use (Consumption)[b]	**38.6**	**43.6**	**45.9**	**46.5**	**54.8**	
Electricity Production (in-state)	29.8	35.1	34.0	34.3	39.6	*See electric sector assumptions*
Coal	23.9	30.5	28.8	30.3	35.0	*in appendix A.*
Natural Gas	1.60	1.98	1.52	1.50	1.95	
Oil	4.22	2.42	3.52	2.19	2.35	
Wood	0.003	0.003	0.004	0.009	0.011	
MSW/LFG	0.03	0.21	0.19	0.20	0.22	
Net Imported Electricity	8.83	8.55	11.82	12.27	15.25	
Residential/Commercial/Industrial (RCI) Fuel Use	**21.1**	**19.1**	**20.0**	**20.2**	**20.7**	
Coal	5.54	2.14	3.21	3.23	3.21	Based on US DOE regional projections
Natural Gas	8.25	9.80	9.94	10.4	11.3	Based on US DOE regional projections
Petroleum	7.27	7.04	6.79	6.43	6.16	Based on US DOE regional projections
Wood	0.08	0.10	0.08	0.08	0.07	Based on US DOE regional projections
Transportation	**24.2**	**29.9**	**32.5**	**34.8**	**40.9**	
Onroad Gasoline	17.9	21.6	23.9	25.3	28.8	Based on MDE VMT projections.
Onroad Diesel	2.91	5.09	5.89	6.83	9.18	Based on MDE VMT projections.
Marine Vessels	1.36	1.29	1.18	1.15	1.30	
Rail, Natural Gas, and LPG	0.53	0.22	0.20	0.22	0.25	Based on US DOE regional projections.
Jet Fuel and Aviation Gasoline	1.49	1.68	1.31	1.32	1.42	Based on FAA operations projections.
Fossil Fuel Industry	**0.97**	**0.99**	**1.08**	**1.12**	**1.11**	
Natural Gas Industry	0.76	0.85	0.91	0.91	0.90	Based on historical growth and AEO2006 regional natural gas consumption
Coal Mining	0.21	0.13	0.17	0.21	0.22	Based on AEO2006 coal production growth rates for Northern Appalachia region
Industrial Processes	**2.58**	**3.78**	**4.90**	**6.17**	**8.70**	
Cement Manufacture	0.86	0.86	1.27	1.45	1.82	15-year historical trend in clinker production

	Limestone and Dolomite	0.09	0.09	0.11	0.11	0.12	15-year historical trend in consumption
	Soda Ash	0.05	0.05	0.05	0.05	0.05	15-year historical trend in consumption
	Iron and Steel	0.83	0.75	0.60	0.56	0.50	1997-2005 historical trend in production
	ODS Substitutes	0.01	1.53	2.31	3.44	5.63	National emissions projections (US EPA)
	Electricity Transmission and Dist.	0.50	0.27	0.25	0.23	0.21	National emissions projections (US EPA)
	Semiconductor Manufacturing	0.003	0.009	0.007	0.007	0.005	National emissions projections (US EPA)
	Aluminum Production	0.25	0.23	0.30	0.33	0.37	15-year historical trend in production
Agriculture		**2.11**	**2.31**	**1.80**	**1.93**	**1.87**	
	Enteric Fermentation	0.47	0.38	0.35	0.33	0.33	Based on projected livestock population
	Manure Management	0.34	0.33	0.30	0.32	0.32	Based on projected livestock population
	Agricultural Soils	1.29	1.59	1.14	1.28	1.22	Based on 1990-2005 emissions growth
	Agricultural Burning	0.01	0.01	0.01	0.01	0.01	Based on 1990-2005 emissions growth
Waste Management		**2.86**	**3.27**	**3.26**	**3.30**	**3.40**	
	Waste Combustion	0.00	0.00	0.00	0.00	0.00	Emissions included in the electric sector
	Landfills	2.24	2.57	2.52	2.52	2.52	Based on 1995-2005 emissions growth.
	Wastewater Management	0.58	0.67	0.70	0.75	0.85	Based on 1995-2005 emissions growth.
	Residential Open Burning	0.03	0.03	0.03	0.03	0.03	Based on 2000 data with no growth.
Gross Emissions (Consumption Basis, Excludes Sinks)		**92.4**	**103.0**	**109.4**	**114.0**	**131.5**	
	increase relative to 1990		*11%*	*18%*	*23%*	*42%*	
Emissions Sinks		**-7.9**	**-11.5**	**-11.7**	**-11.9**	**-12.3**	
	Forested Landscape	-2.08	-8.89	-8.89	-8.89	-8.89	Based on estimates from the USFS
	Urban Forestry and Land Use	-5.69	-2.42	-2.62	-2.86	-3.27	
	Agricultural Soils (Cultivation Practices)	-0.15	-0.15	-0.15	-0.15	-0.15	Historical and projected emissions held constant at 1997 levels
Net Emissions (Consumptions Basis) (Including forestry, land use, and ag sinks)		**84.5**	**91.5**	**97.8**	**102.1**	**119.2**	
	increase relative to 1990		*8%*	*16%*	*21%*	*41%*	

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

[b] Note that electricity sector emission reductions attributable to the Regional Greenhouse Gas Initiative (RGGI) are not included in the reference case emissions inventory. Reductions from RGGI are illustrated in Appendix A.

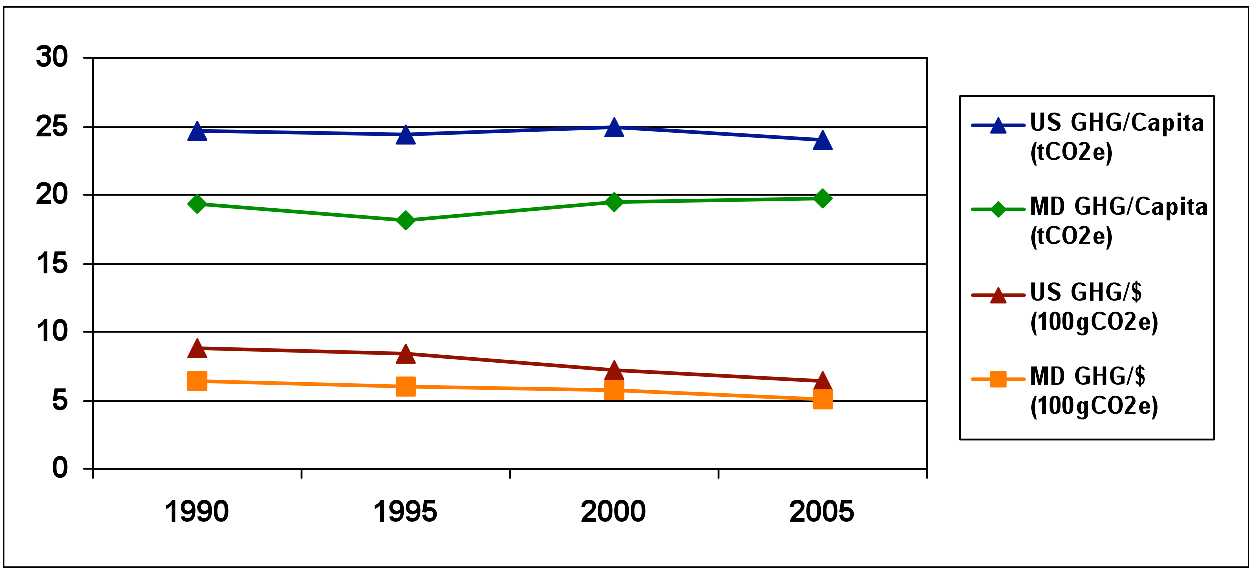
Historical Emissions

Overview

These analyses suggest that in 2005, activities in Maryland accounted for approximately 109 million metric tons (MMt) of gross CO_2e emissions (consumption basis), an amount equal to about 1.5% of total US gross GHG emissions in 2005.[11] Maryland's gross GHG emissions are rising at a slightly faster rate than those of the nation as a whole (gross emissions exclude carbon sinks, such as forests). Maryland's gross GHG emissions increased by about 18% from 1990 to 2005, while national emissions rose by 16% from 1990 to 2005. The growth in Maryland's emissions from 1990 to 2005 is primarily associated with the transportation and electricity consumption sectors.

On a gross emissions per capita basis, Maryland residents emitted about 19.3 metric tons (t) of gross CO_2e in 1990, lower than the national average of 24.6 tCO_2e in 1990. Per capita emissions in Maryland increased to 19.7 tCO_2e/yr by 2005, while the per capita emissions for the US have decreased slightly to 24.0 tCO_2e/yr by 2005. Like the nation as a whole, Maryland's economic growth exceeded gross emissions growth throughout the 1990-2005 period (leading to declining estimates of GHG emissions per unit of state product). From 1990 to 2005, gross emissions per unit of gross product dropped by 27% nationally, and by 21% in Maryland.[12]

Figure 1. Historical Maryland and US Gross GHG Emissions, Per Capita and Per Unit Gross Product

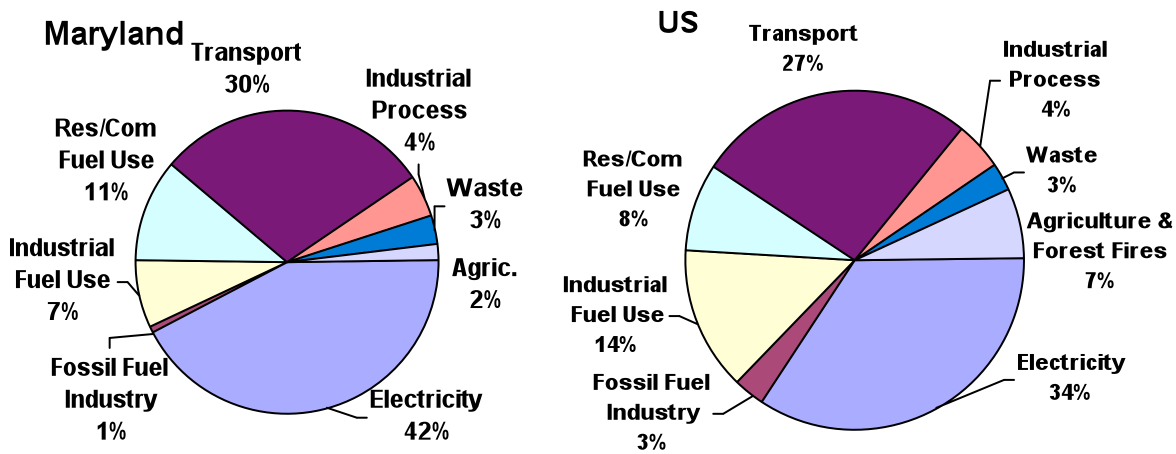


[11] US 2005 emissions estimates are from *Inventory of US Greenhouse Gas Emissions and Sinks: 1990–2006*, April 15, 2008, US EPA # 430-R-08-005, (http://www.epa.gov/climatechange/emissions/usinventoryreport.html).

[12] Based on real gross domestic product (millions of chained 2000 dollars) that excludes the effects of inflation, available from the US Bureau of Economic Analysis (http://www.bea.gov/regional/gsp/). The national emissions used for these comparisons are based on 2005 emissions from the 2008 version of EPA's GHG inventory report (http://www.epa.gov/climatechange/emissions/usinventoryreport.html).

Figure 2 compares gross GHG emissions estimated for Maryland to emissions for the US for year 2005. Principal sources of Maryland's GHG emissions are the electricity consumption and transportation sectors, accounting for 42% and 30% of Maryland's gross GHG emissions in 2005, respectively. The next largest contributor is residential, commercial, and industrial fuel use (RCI), accounting for 18% of gross GHG emissions in 2005. The waste management and agriculture sectors each contribute 3% and 2% of gross GHG emissions in 2005, respectively.

Figure 2. Gross GHG Emissions by Sector, 2005, Maryland and US



Industrial process emissions comprised 4% of State GHG emissions in 2005. Industrial process emissions are rising rapidly due to the increasing use of HFCs as substitutes for ozone-depleting chlorofluorocarbons (CFCs), and their overall contribution is estimated to grow to be 7% of Maryland's gross GHG emissions in 2020.[13] Other industrial process emissions result from CO_2 released during cement manufacture; soda ash, limestone, and dolomite use; and iron and steel production; releases of SF_6 from transformers used in the transmission and distribution (T&D) of electricity; PFC emissions from aluminum production; and emissions of HFC, PFC, and SF_6 from semiconductor manufacturing.

Methane emissions associated with the extraction and distribution of fossil fuels accounted for 1% of the State's gross GHG emissions in 2005. In Maryland, methane releases to the atmosphere are associated with the operation of natural gas wells, natural gas T&D, and surface and sub-surface coal mining.

The forests and agricultural soils are net sinks of GHG emissions in Maryland, sequestering 12 MMtCO2e in 2005. Overall, activities associated with forestry (including both landscape and urban forests), land use changes, and the cultivation of agricultural soils in Maryland are estimated to be net sinks of GHG emissions throughout the period from 1990 through 2020. Through sequestration, forested lands in Maryland are expected to store about 7.8 $MMtCO_2e$ in

[13] CFCs are also potent GHGs; they are not, however, included in GHG estimates because of concerns related to implementation of the Montreal Protocol (See Appendix I for additional information). HFCs are used as refrigerants in the RCI and transport sectors as well as in the industrial sector; they are included here, however, within the industrial processes emissions.

1990, increasing to 11.5 MMt CO_2e in 2005, and to 12.2 MMt CO_2e by 2020. The cultivation of agricultural soils is estimated to result in a net sink of about 0.15 $MMtCO_2e$ throughout the 1990 to 2020 period.

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

Electricity Supply Sector

Maryland is a net importer of electricity, meaning that the State consumes more electricity than is produced in the State. For this analysis, it was assumed that all power generated in Maryland was consumed in Maryland, and that remaining electricity demand was met by imported power. Sales associated with imported power accounted for 35% of the electricity consumed in Maryland in 2005.[14] GHG emissions from power produced in-state are dominated by coal use, followed by emissions from oil use and natural gas use. As shown in Figure 2, electricity consumption accounted for about 42% of Maryland's gross GHG emissions in 2005 (about 46 $MMtCO_2e$), which was higher than the national average share of emissions from electricity consumption (34%).[15] The GHG emissions associated with Maryland's electricity sector increased by about 7 $MMtCO_2e$ between 1990 and 2005, accounting for 43% of the state's net growth in gross GHG emissions in this time period.

In 2005, emissions associated with Maryland's electricity consumption (46 $MMtCO_2e$) were about 12 $MMtCO_2e$ higher than those associated with electricity production (34.0 $MMtCO_2e$). The higher level for consumption-based emissions reflects GHG emissions associated with net imports of electricity to meet Maryland's electricity demand.[16] Projections of electricity sales for 2005 through 2020 indicate that Maryland will remain a net importer of electricity. For the period covering 2005 through 2020, the reference case projection assumes that production-based emissions (associated with electricity generated in-state) will increase by about 6 $MMtCO_2e$, and consumption-based emissions (associated with electricity consumed in-state) will increase by about 9 $MMtCO_2e$.

The consumption-based approach can better reflect the emissions (and emissions reductions) associated with activities occurring in Maryland, particularly with respect to electricity use (and efficiency improvements), and is particularly useful for policy-making.

Transportation Sector

As shown in Figure 2, the transportation sector accounted for about 30% of Maryland's gross GHG emissions in 2005 (about 33 $MMtCO_2e$), which was higher than the national average share of emissions from transportation fuel consumption (27%). The GHG emissions associated with

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[14] In 2005, total Maryland retail sales were 68,365 GWh, of which 21,870 (i.e., 35%) were estimated to be from imports.

[15] For the US as a whole, there is relatively little difference between the emissions from electricity use and emissions from electricity production, as the US imports only about 1% of its electricity, and exports even less. Maryland's situation is different, since it is a net electricity importer.

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

Maryland's transportation sector increased by 8 $MMtCO_2e$ between 1990 and 2005, accounting for about 49% of the State's net growth in gross GHG emissions in this time period.

From 1990 through 2005, Maryland's GHG emissions from transportation fuel use have risen steadily at an average rate of about 2.0% annually. In 2005, onroad gasoline vehicles accounted for about 74% of transportation GHG emissions. Onroad diesel vehicles accounted for another 18% of emissions, and air travel for roughly 4%. Marine vessels, rail, and other sources (natural gas- and liquefied petroleum gas- (LPG-) fueled-vehicles used in transport applications) accounted for the remaining 4% of transportation emissions. As a result of Maryland's population and economic growth and an increase in total vehicle miles traveled (VMT) during the 1990s, emissions from onroad gasoline use grew about 34% between 1990 and 2005. Meanwhile, emissions from onroad diesel use more than doubled, rising by 103% during that period, suggesting an even more rapid growth in freight movement within or across the State. Emissions from marine fuel use decreased by about 13% from 1990 to 2005, while emissions from rail fuel use decreased about 85% in the same period.

Reference Case Projections (Business as Usual)

Relying on a variety of sources for projections, as noted below and in the appendices, we developed a simple reference case projection of GHG emissions through 2020. As illustrated in Figure 3 and shown numerically in Table 1, under the reference case projections, Maryland's gross GHG emissions continue to grow steadily, climbing to about 132 $MMtCO_2e$ by 2020, 42% above 1990 levels.[17] The electricity consumption sector is projected to be the largest contributor to future emissions growth, followed by emissions associated with transportation and then by ODS substitutes (HFCs), as shown in Figure 4.

Maryland Greenhouse Gas & Carbon Mitigation Working Group Revisions

The following identifies the revisions recommended or approved by the Maryland GHG & Carbon Mitigation Working Group to the inventory and reference case projections, thus explaining the differences between this report and the initial assessment completed during January 2008:

- Energy Supply: Two major changes were made from the first draft of the energy supply inventory and forecast. First, a Maryland-specific electricity sales projection was used instead of the average from the surrounding NERC regions. Second, a Maryland-specific electricity generation projection was used instead of the average from the surrounding NERC regions. These changes resulted in an increase of 2.0 $MMtCO_2e$ emissions from the draft 2020 electricity consumption total of 52.8 $MMtCO_2e$ to the current 2020 estimate of 54.8 $MMtCO_2e$ emissions.

- Fossil Fuel Production and Distribution Industry: Estimates for combustion of natural gas consumed by internal combustion engines to operate pipeline systems in Maryland

[17] Note that electricity sector emission reductions attributable to the Regional Greenhouse Gas Initiative (RGGI) are not included in the reference case emissions inventory. Reductions from RGGI are illustrated in Appendix A.

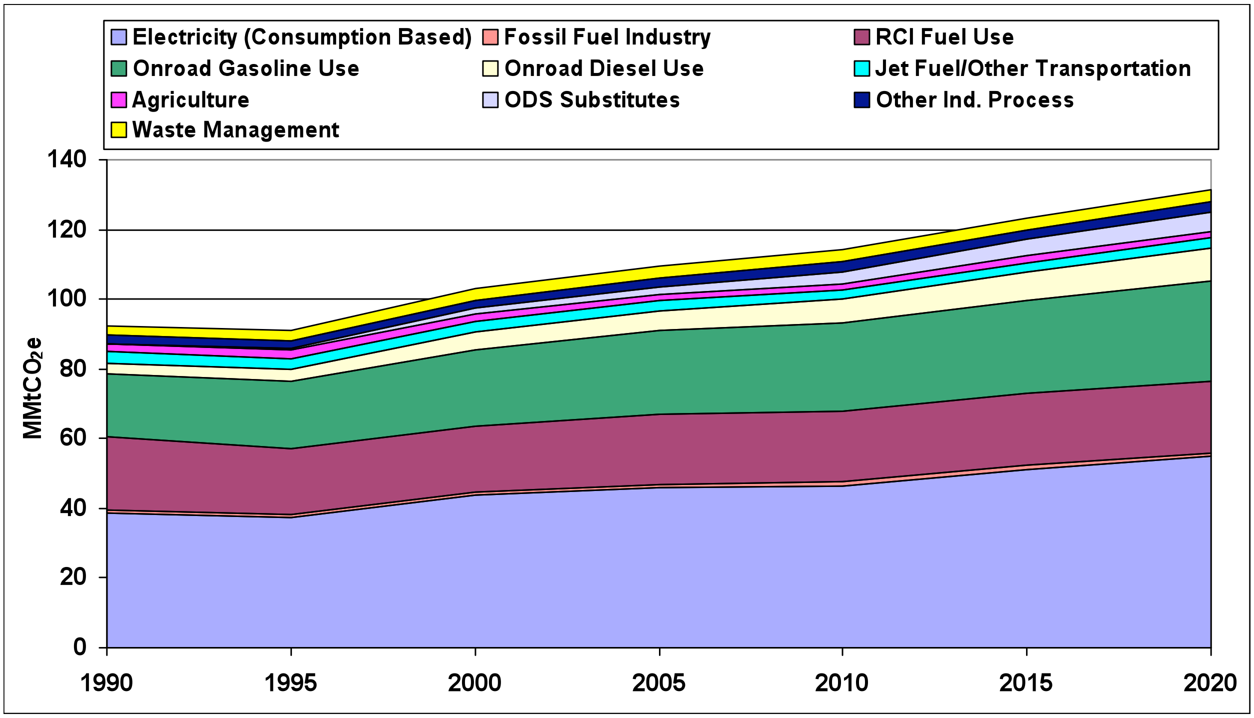
based on SED data were added for 1990 through 2005. In addition, post-2005 emissions were projected using a -0.54%/year rate of decline, representing the state trend in pipeline fuel use over the 1990-2005 period.

- Industrial Processes: As documented in the January draft inventory and forecast report, the growth rate for the iron and steel industry should be -1.4% per year. However, a different growth rate had actually been applied to the iron and steel emissions to estimate the 2006-2020 emissions. The growth rate of -1.4% has been correctly applied to the iron and steel emissions in this final version. This change results in a reduction of the 2020 iron and steel emissions from 0.57 $MMtCO_2e$ to 0.50 $MMtCO_2e$.

Key Uncertainties and Next Steps

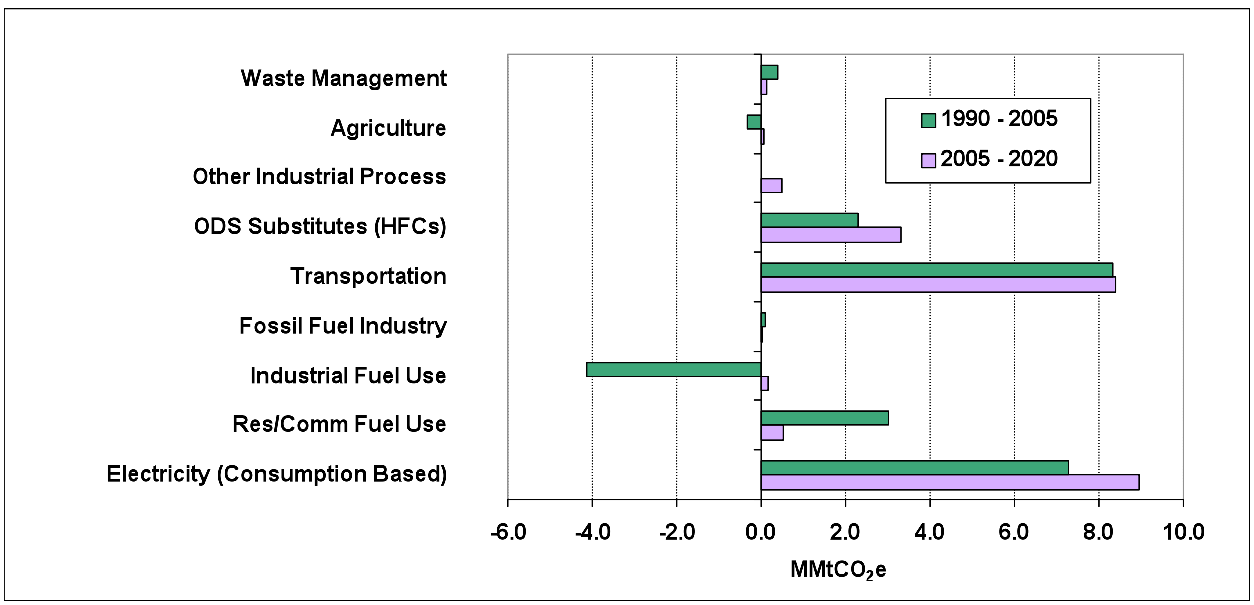
Some data gaps exist in this inventory, and particularly in the reference case projections. Key tasks for future refinement of this inventory and forecast include review and revision of key drivers, such as the transportation, electricity demand, and RCI fuel use growth rates that will be major determinants of Maryland's future GHG emissions (See Table 2 and Figure 4). These growth rates are driven by uncertain economic, demographic and land use trends (including growth patterns and transportation system impacts), all of which deserve closer review and discussion.

Figure 3. Maryland Gross GHG Emissions by Sector, 1990-2020: Historical and Projected



RCI – direct fuel use in residential, commercial, and industrial sectors. ODS – ozone depleting substance.

Figure 4. Sector Contributions to Gross Emissions Growth in Maryland, 1990-2020: Historic and Reference Case Projections ($MMtCO_2e$ Basis)



Res/Comm – direct fuel use in residential and commercial sectors. ODS – ozone depleting substance. HFCs – hydrofluorocarbons. Emissions associated with other industrial processes include all of the industries identified in Appendix D except emissions associated with ODS substitutes which are shown separately in this graph because of high expected growth in emissions for ODS substitutes.

Table 2. Key Annual Growth Rates for Maryland, Historical and Projected

	1990-2005	2005-2020	Sources
Population[a]	1.01%	0.86%	Maryland Department of Planning, Planning Data Services[18]
Electricity Sales **Total Sales**[c] **MD Sales**[d] **Imported Sales**[e]	 2.2% 2.9% 0.9%	 1.5% 1.6% 1.3%	Inventory period: the total sales growth rate was calculated using historical data for 1990 and 2005 from EIA's State Electricity Profiles; the MD sales growth rate was calculated for 1990 and 2005 using historical data after netting out transmission and distribution losses from net generation statistics; the imported sales growth rate was calculated as the difference between total sales and MD sales for 1990 and 2005. Forecast period: the total, MD and imported sales annual growth rates for 2005-2020 were based on the MD PSC reported entitled, "ELECTRIC SUPPLY ADEQUACY REPORT OF 2007, In compliance with Section 7-505(e) of the Public Utility Companies Article" for the period 2005-2016 (page 9-10).
Vehicle Miles Traveled	2.3%	1.7%	Maryland Department of the Environment

[a] For the RCI fuel use sectors, growth in annual fuel consumption by sector and type of fuel was calculated from the US DOE EIA's Annual Energy Outlook 2006 (AEO2006) projections of changes in fuel use for the EIA's South Atlantic region. Regional growth rates for the residential sector are adjusted for Maryland's projected population. For instance, growth in Maryland's residential natural gas use is calculated as the Maryland population growth times the change in per capita natural gas use for the South Atlantic region.
[c] Represents annual growth in total sales of electricity met by generators located within and outside Maryland to RCI sectors located within Maryland (consumption basis).
[d] Represents annual growth in total sales of electricity by generators in Maryland to RCI sectors located within Maryland (production basis). Annual growth rate calculated using data for 1990 and 2003.
[e] Represents annual growth rate in sales of electricity imported into Maryland.

Approach

The principal goal of compiling the inventories and reference case projections presented in this document is to provide MDE with a general understanding of Maryland's historical, current, and projected (expected) GHG emissions. The following sections explain the general methodology and the general principles and guidelines followed during development of these GHG inventories for Maryland.

General Methodology

We prepared this analysis in close consultation with Maryland agencies, in particular, with the MDE staff. The overall goal of this effort is to provide simple and straightforward estimates, with an emphasis on robustness, consistency, and transparency. As a result, we rely on reference forecasts from best available State and regional sources where possible. Where reliable existing forecasts are lacking, we use straightforward spreadsheet analysis and constant growth-rate extrapolations of historical trends rather than complex modeling.

[18] Maryland Department of Planning, Planning Data Services. Population data for 1990, 2000, and estimated 2006, 2010, 2020, and 2030 downloaded from http://www.msa.md.gov/msa/mdmanual/01glance/html/pop.html#state.

In most cases, we follow the same approach to emissions accounting for historical inventories used by the US EPA in its national GHG emissions inventory[19] and its guidelines for States.[20] These inventory guidelines were developed based on the guidelines from the Intergovernmental Panel on Climate Change (IPCC), the international organization responsible for developing coordinated methods for national GHG inventories.[21] The inventory methods provide flexibility to account for local conditions. The key sources of activity and projection data used are shown in Table 3. Table 3 also provides the descriptions of the data provided by each source and the uses of each data set in this analysis.

General Principles and Guidelines

A key part of this effort involves the establishment and use of a set of generally accepted accounting principles for evaluation of historical and projected GHG emissions, as follows:

- **Transparency:** We report data sources, methods, and key assumptions to allow open review and opportunities for additional revisions later based on input from others. In addition, we report key uncertainties where they exist.
- **Consistency:** To the extent possible, the inventory and projections were designed to be externally consistent with current or likely future systems for State and national GHG emission reporting. We have used the EPA tools for State inventories and projections as a starting point. These initial estimates were then augmented and/or revised as needed to conform with State-based inventory and base-case projection needs. For consistency in making reference case projections, we define reference case actions for the purposes of projections as those *currently in place or reasonably expected over the time period of analysis*.
- **Priority of Existing State and Local Data Sources:** In gathering data and in cases where data sources conflicted, we placed highest priority on local and State data and analyses, followed by regional sources, with national data or simplified assumptions such as constant linear extrapolation of trends used as defaults where necessary.
- **Priority of Significant Emissions Sources:** In general, activities with relatively small emissions levels may not be reported with the same level of detail as other activities.

Table 3. Key Sources for Maryland Data, Inventory Methods, and Growth Rates

Source	Information provided	Use of Information in this Analysis
US EPA State Greenhouse Gas Inventory Tool (SIT)	US EPA SIT is a collection of linked spreadsheets designed to help users develop State GHG inventories for 1990-2005. US EPA SIT contains default data for each State for most of the information required for an inventory. The SIT methods are based on the methods provided in the Volume VIII document series published by the Emissions Inventory Improvement Program (http://www.epa.gov/ttn/chief/eiip/techreport/volum	Where not indicated otherwise, SIT is used to calculate emissions for 1990-2005 from RCI fuel combustion, transportation, industrial processes, agriculture and forestry, and waste. We use SIT emission factors (CO_2, CH_4, and N_2O per British thermal unit (Btu) consumed) to calculate energy use emissions.

[19] US EPA 2008, *Inventory of US Greenhouse Gas Emissions and Sinks: 1990 to 2006*; (http://www.epa.gov/climatechange/emissions/usinventoryreport.html).
[20] http://yosemite.epa.gov/oar/globalwarming.nsf/content/EmissionsStateInventoryGuidance.html.
[21] http://www.ipcc-nggip.iges.or.jp/public/gl/invs1.htm.

Source	Information provided	Use of Information in this Analysis
	e08/index.html).	
US DOE Energy Information Administration (EIA) State Energy Data (SED)	EIA SED provides energy use data in each State, annually to 2005 for all RCI sectors and fuels.	EIA SED is the source for most energy use data. Emission factors from US EPA SIT are used to calculate energy-related emissions.
EIA AEO2006	EIA AEO2006 projects energy supply and demand for the US from 2003 to 2030. Energy consumption is estimated on a regional basis. Maryland is included in the South Atlantic region (SC, DE, MD, DC, WV, VA, NC, GA, FL). Also used to provide projected mix of onroad vehicles and aircraft efficiency gains for transportation sector.	EIA AEO2006 is used to project changes in fuel use for the RCI sectors and the mix of VMT by vehicle type in the projection years. Aircraft efficiency gains are used to adjust the aviation growth factors.
EIA State Electricity Profiles	EIA provides information on the electric power industry generation by primary energy source for 1990 – 2005.	EIA State Electricity Profiles were used to determine the mix of in-state electricity generation by fuel.
US Department of Transportation (DOT), Office of Pipeline Safety (OPS)	Natural gas transmission pipeline mileage, and distribution pipeline mileage and number of services for 1990 – 2005.	OPS historical pipeline mileage and number of services used as input to SIT to calculate historical emissions from natural gas industry.
US EPA GHG Inventory and Sinks Report	CH_4 emissions from coal mining.	Provided historical CH_4 emission estimates from coal mining.
MDE	MDE provided landfill emplacement and control data for Maryland landfills and VMT data	Waste emplacement data used to estimate emissions from solid waste management. VMT used to estimate onroad CH_4 and N_2O emissions and to project all onroad emissions.
Federal Aviation Administration (FAA)	Aircraft operation projections for Maryland.	Aircraft operation data used in calculating aviation growth factors.
US Forest Service	Data on forest carbon stocks and land use cover for multiple years.	Data are used to calculate CO_2 flux over time (terrestrial CO_2 sequestration in forested areas).
USDS National Agricultural Statistics Service (NASS)	USDA NASS provides data on crops and livestock.	Crop production data used in SIT to estimate agricultural residue and agricultural soils emissions; livestock population data used in SIT to estimate manure and enteric fermentation emissions.

- **Comprehensive Coverage of Gases, Sectors, State Activities, and Time Periods:** This analysis aims to comprehensively cover GHG emissions associated with activities in Maryland. It covers all six GHGs covered by US and other national inventories: CO_2, CH_4, N_2O, SF_6, HFCs, and PFCs. The inventory estimates are for the year 1990, with subsequent years included up to most recently available data (typically 2002 to 2005), with projections to 2010 and 2020.
- **Use of Consumption-Based Emissions Estimates:** To the extent possible, we estimated emissions that are caused by activities that occur in Maryland. For example, we reported emissions associated with the electricity consumed in Maryland. The rationale for this method of reporting is that it can more accurately reflect the impact of State-based policy strategies such as energy efficiency on overall GHG emissions, and it resolves double-

counting and exclusion problems with multi-emissions issues. This approach can differ from how inventories are compiled, for example, on an in-state production basis, in particular for electricity.

For electricity, we estimate, in addition to the emissions due to fuels combusted at electricity plants in the State, the emissions related to electricity *consumed* in Maryland. This entails accounting for the electricity sources used by Maryland utilities to meet consumer demands. As this analysis is refined in the future, one could also attempt to estimate other sectoral emissions on a consumption basis, such as accounting for emissions from transportation fuel used in Maryland, but purchased out-of-state. In some cases, this can require venturing into the relatively complex terrain of life-cycle analysis. In general, we recommend considering a consumption-based approach where it will significantly improve the estimation of the emissions impact of potential mitigation strategies. For example re-use, recycling, and source reduction can lead to emission reductions resulting from lower energy requirements for material production (such as paper, cardboard, and aluminum), even though production of those materials, and emissions associated with materials production, may not occur within the State.

Details on the methods and data sources used to construct the inventories and forecasts for each source sector are provided in the following appendices:

- Appendix A. Electricity Use and Supply
- Appendix B. Residential, Commercial, and Industrial (RCI) Fuel Combustion
- Appendix C. Transportation Energy Use
- Appendix D. Industrial Processes
- Appendix E. Fossil Fuel Extraction and Distribution Industry
- Appendix F. Agriculture
- Appendix G. Waste Management
- Appendix H. Forestry

Appendix I provides additional background information from the US EPA on GHGs and global warming potential values.

Appendix A. Electricity Supply

This appendix describes the data sources, key assumptions, and the methodology used to develop an inventory of greenhouse gas (GHG) emissions over the 1990-2005 period associated with meeting electricity demand in Maryland. It also describes the data sources, key assumptions, and methodology used to develop a forecast of GHG emissions over the 2006-2020 period associated with meeting electricity demand in the state. Specifically, the following topics are covered in this Appendix:

- *Data sources:* This section provides an overview of the data sources that were used to develop the inventory and forecast, including publicly accessible websites where this information can be obtained and verified.
- *Greenhouse Gas Inventory methodology:* This section provides an overview of the methodological approach used to develop of the Maryland GHG inventory for the electric supply sector.
- *Greenhouse Gas Forecast Methodology – Reference Case:* This section provides an overview of methodological approach used to develop the Maryland GHG Reference Case forecast for the electric supply sector. This forecast does not include the impact of RPS (Renewable Portfolio Standard) legislation.
- *Greenhouse Gas Forecast Methodology – Alternative Reference Case:* This section provides an overview of methodological approach used to develop the Maryland GHG Alternative Reference Case forecast for the electric supply sector. This forecast includes the impact of RPS legislation.
- *Greenhouse Gas Inventory Results:* This section provides an overview of key results of the Maryland GHG inventory for the electric supply sector.
- *Greenhouse Gas Forecast Results:* This section provides an overview of key results of the Maryland GHG forecast for the electric supply sector. The results of both Reference Cases are presented.

Data Sources

We considered several sources of information in the development of the inventory and forecast of carbon dioxide equivalent (CO_2e) emissions from Maryland power plants. These are briefly summarized below:

- *2005 EIA-906/920 Monthly Time Series data.* This is a database file available from the Energy Information Administration (EIA) of the US Department of Energy. The information in the database is based on information collected from utilities in Forms EIA-906/920 and EIA-860 for the forecast Base Year of 2005. Data from these forms provide, among other things, fuel consumption and net generation in power stations by plant type. This information can be accessed from http://www.eia.doe.gov/cneaf/electricity/page/eia906_920.html.

- *Annual Energy Outlook 2007.* This is an output of an EIA analysis using the National Energy Modeling System (NEMS), a model that forecasts electric expansion/electricity demand in the USA. In particular, regional outputs for Mid-Atlantic Area Council (MAAC) and East Central Area Reliability Coordination region (ECAR) region were used. The MAAC/ECAR regions are the ones in which Maryland is located (see map at right). The results include forecasts of gross generation, net generation, combustion efficiency, total sales, and exports/imports through the year 2025. This information is available in supplemental tables that can be accessed directly from http://www.eia.doe.gov/oiaf/aeo/supplement/index.html. The sources of the above map is http://www.bydesign.com/fossilfuels/crisis/html/NERC_regions_map.html.

North American Electric Reliability Council Region Map—(US)

- *Monthly Cost and Quality of Fuels for Electric Plants.* This information is available from the Federal Energy Regulatory Commission (FERC). The database relies on information collected from utilities in the FERC-423 form. It was used to determine the share of coal type (i.e., whether bituminous, sub-bituminous, anthracite, or lignite) as well as the coal quantity consumed in Maryland power plants over the period 1990-2005. It can be accessed directly from http://www.eia.doe.gov/cneaf/electricity/page/ferc423.html.

- *State Electricity Profiles.* This information is available from the EIA. The database compiles capacity, net generation, and total retail electricity sales by state. It was used to determine total sales of electricity across all sectors in the Base Year 2005. It can be accessed directly from http://www.eia.doe.gov/cneaf/electricity/st_profiles/e_profiles_sum.html.

- *Energy conversion factors.* This is based on Table Y-2 of Appendix Y in the USEPA's 2003 GHG Inventory for the USA. The table is entitled "Conversion Factors to Energy Units (Heat Equivalents)". This information can be accessed directly from the following website: http://yosemite.epa.gov/oar/globalwarming.nsf/UniqueKeyLookup/LHOD5MJTCL/$File/2003-final-inventory_annex_y.pdf.

- *Fuel combustion oxidation factors:* This is based on Appendix A of the USEPA's 2003 US GHG inventory for the USA. This information can be accessed directly from: http://www.epa.gov/climatechange/emissions/downloads06/06_Annex_Chapter2.pdf.

- *Carbon dioxide, methane, and nitrous oxide emission factors.* For all fuels except MSW, these emission factors are based on Appendix A of the USEPA's 2003 GHG inventory for the USA. This information can be accessed directly from: http://www.epa.gov/climatechange/emissions/downloads06/06_Annex_Chapter2.pdf. For MSW, emission factors are based on the Energy Information Administration, Office of

Integrated Analysis and Forecasting, Voluntary Reporting of Greenhouse Gases Program, Table of Fuel and Energy Source: Codes and Emission Coefficients. This information can be accessed directly from http://www.eia.doe.gov/oiaf/1605/coefficients.html.

- *Global warming potentials:* These are based on values proposed by the Intergovernmental Panel on Climate Change (IPCC) Third Assessment Report. This information can be accessed directly from http://www.ipcc.ch/pub/reports.htm.

Greenhouse Gas Inventory Methodology

The methodology used to the develop the Maryland inventory of GHG emissions associated with electricity production and consumption is based on methods developed by the IPCC and used by the USEPA in the development of the US GHG inventory. There are four fundamental premises of the GHG inventory developed for Maryland, as briefly described below:

- The GHG inventory should be estimated based on both the production and consumption of electricity. Developing the production estimate involves tallying up the GHG emissions associated with the operation of power plants physically located in Maryland, regardless of ownership. Developing the consumption estimate involves tallying up the GHG emissions associated with consumption of electricity in Maryland, regardless of where the electricity is produced. As Maryland is a net importer of electricity, these estimates will be different.
- The GHG inventory is based on emissions at the point of electric generation only. That is, GHG emissions associated with upstream fuel cycle process such as primary fuel extraction, transport to refinery/processing stations, refining, beneficiation, and transport to the power station are not included as they are addressed in other portions of the Maryland GHG inventory.
- As an approximation, it was assumed that all power generated in Maryland was consumed in Maryland. However, given the similarity in the average carbon intensity of Maryland power stations and that of power stations in the surrounding MAAC/ECAR region, the potential error associated with this simplifying assumption is small, on the order of 2%, plus or minus.
- Several key assumptions were used for making projections of CO_2, methane (CH_4), and nitrous oxide (N_2O) emissions for the electric sector out to 2020. These are summarized in Table A1.

Table A1. Key Assumptions used in the Maryland GHG Forecast

Key Assumptions	2005	2020	Average Annual Growth / Change (%)
MD Electricity Demand (GWh)	68,365	85,216	1.5%
MD Gross generation (GWh)	53,108	66,482	1.5%
MD Gross generation to meet MD demand (GWh)	76,619	94,618	1.4%
Gross generation associated with net imports from MAAC/ECAR regions (GWh)	23,511	28,135	1.2%
Power plant heat rate (BTU/kWh)			
Coal	10,500	9,054	-1.0%
Natural Gas	11,642	11,342	-0.2%
Petroleum	11,750	12,871	0.6%
Nuclear	10,582	10,582	0.0%
Hydroelectric	10,320	10,320	0.0%
Wind	10,320	10,320	0.0%
MSW Landfill gas	10,500	10,500	0.0%
Losses (%)			
From on-site usage	1.1%	0.8%	-2.2%
From T&D and on-site usage	6.1%	5.4%	-0.8%

There were several steps in the methodology for the development of the electric sector GHG inventory for the period 1990-2005. These are briefly outlined below:

- Determine the coal quality used in Maryland power stations (i.e., share of anthracite, bituminous, lignite, sub-bituminous, and coal wastes used).
- Determine gross annual primary energy consumption by Maryland power stations by plant and fuel type.
- Determine gross annual generation associated with net power imports to satisfy Maryland electricity demand.
- Multiply gross annual primary energy consumption by Maryland power stations by CO_2e emission factors. This provides an estimate of the Maryland GHG inventory on a production basis.
- Multiply annual gross generation associated with net power imports by the carbon emission intensity (in units of metric tons CO_2-equivalent per megawatt-hour [CO_2e/MWh]) of the MAAC/ECAR region. This provides an estimate of the additional GHG emissions associated with meeting Maryland electricity demand in excess of generation from local power plants.
- Add the emissions associated with net power imports to the production-based emissions. This provides an estimate of the GHG inventory on a consumption basis.

Greenhouse Gas Forecast Methodology – Reference Case

We consider that the most useful methodology for constructing a GHG forecast is one that attempts to build information from the bottom-up. That is, the GHG forecast in developed using detailed State-specific data regarding projected sales, gross in-state generation, supply side efficiency improvements, planned capacity additions and retirements by plant type/vintage, and changes over time regarding losses associated with on-site use and transmission and distribution.

While some of this information was available in Maryland, some key data was not available at the time the forecast was prepared. Therefore, it was necessary to use a top-down approach. A top-down approach uses proxy information regarding future gross in-state generation, supply side efficiency improvements, and changes over time regarding losses. This approach, while less satisfactory for representing state-specific conditions, nonetheless offers an acceptable starting point for exploring projections of GHG emissions from the electric sector in Maryland. The methodological steps used for forecasting CO_2e emissions are described below.

Coal quality. An overview of the methodology applied to forecast annual gross electricity generation by Maryland power stations is briefly summarized below:

- For the Base Year of 2005, determine the coal quality used in Maryland power stations (i.e., share of anthracite, bituminous, lignite, sub-bituminous, and coal wastes used).
- For the period 2006 through and including 2020, assume that the coal quality is the same for the Base year.

Total Sales. An overview of the methodology applied to forecast annual sales of electricity to Maryland consumers is briefly summarized below:

- For the Base Year of 2005, establish total retail sales in Maryland (i.e. 68,365 gigawatt-hour (GWh)).
- For the period 2006 through and including 2016, assume the growth rate for in-state electricity sales is consistent with the report entitled "ELECTRIC SUPPLY ADEQUACY REPORT OF 2007". This report was prepared by the Maryland PSC in compliance with Section 7-505(e) of the Public Utility Companies Article (page 9-10). For the period 2017-2020, the average annual growth rate from the 2006-2016 period was used.

Gross Generation for utilities and non-utilities. An overview of the methodology applied to forecast annual gross electricity generation by Maryland electric power stations (utilities and non-utilities only) is briefly summarized below:

- For the Base Year of 2005, estimate losses associated with on-site usage of electricity by plant type for Maryland power plants. On-site usage losses were assumed to be equal to the MAAC/ECAR regional average of 0.8% of gross generation.
- For the Base Year of 2005, combine actual net electric generation data (i.e., from the inventory) and assumed average on-site losses (i.e., from the MAAC/ECAR regions) to estimate gross generation by plant type.
- For the period 2006 through and including 2020, estimate total gross generation of Maryland power stations by multiplying the 2005 value of Maryland total gross generation by plant type by the annual growth rate of gross generation in the MAAC/ECAR regions.
- For the period 2006 through and including 2020, multiply plant type-specific gross generation by the annual growth rate of total gross generation in the MAAC/ECAR regions.

Then benchmark the plant type-specific totals pro-rata to match the control total of gross generation.

Gross Generation for cogeneration facilities. An overview of the methodology applied to forecast annual gross electricity generation by commercial and industrial cogeneration facilities in Maryland is briefly summarized below:

- For the Base Year of 2005, estimate the shares of electricity that are sold to the grid and consumed onsite for Maryland cogenerators. On-site usage was assumed to be equal to the MAAC/ECAR regional average of 0.8% of gross generation.
- For the period 2006 through and including 2020, estimate total gross generation of Maryland cogenerators by multiplying the 2005 value of Maryland total gross generation by cogenerator plant type by the annual growth rate of gross generation of cogenerators in the MAAC/ECAR region. Identify the shares of generation used to meet retail and non-retail electricity demand.

Combustion efficiency for utilities and non-utilities. An overview of the methodology applied to forecast annual heat rates at Maryland power stations is briefly summarized below:

- For the Base Year of 2005, estimate average gross heat rate of Maryland power stations by dividing the plant type-specific 2005 gross generation estimate by the plant type-specific 2005 gross primary energy consumption estimate.
- For the period 2006 through and including 2020, estimate the annual average gross plant type-specific heat rate for the MAAC/ECAR region.
- For the period 2006 through and including 2020, estimate annual average gross plant type-specific heat rate of Maryland power stations by multiplying the 2005 value of the annual average gross plant type-specific heat rate of Maryland power plants by the annual rate of improvement of gross heat rate in the MAAC/ECAR region.

Combustion efficiency for cogeneration facilities. An overview of the methodology applied to forecast annual heat rates at Maryland commercial and industrial cogeneration facilities is briefly summarized below:

- For the Base Year of 2005, estimate average gross heat rate of Maryland cogenerators by dividing the plant type-specific 2005 gross generation estimate by the plant type-specific 2005 gross primary energy consumption estimate.
- For the period 2006 through and including 2020, assume the annual average gross plant type-specific heat rate is equal to the 2005 value.

Energy use. An overview of the methodology applied to forecast annual primary energy use at Maryland power stations and cogenerators is briefly summarized below:

- For the Base Year of 2005, establish the actual primary energy consumption for Maryland power plants and cogenerators as reported by the databases used to develop the inventory.
- For the period 2006 through and including 2020, multiply annual gross generation by annual heat rate for each plant type in Maryland.

Electricity imports. An overview of the methodology applied to forecast annual net electricity imports to meet Maryland demand is briefly summarized below:

- For the Base Year of 2005, establish actual total sales of electricity in Maryland.
- For the period 2006 through and including 2020, estimate annual electricity sales in Maryland by multiplying the previous year's sales by the annual growth rate of the MAAC/ECAR region.
- For the Base Year of 2005 through and including 2020, estimate the sales associated with imports as the difference between total sales in Maryland and the total sales by Maryland power stations.
- For the Base Year of 2005 through and including 2020, estimate the gross generation associated with imports by dividing sales from imports by one minus the percent losses from on-site usage and transmission and distribution in the MAAC/ECAR region.

Carbon dioxide-equivalent emissions. An overview of the methodology applied to forecast annual CO_2e emissions is briefly summarized below:

- For the Base Year of 2005 through and including 2020, estimate total CO_2 emissions from Maryland power stations and cogenerators by multiplying total primary energy use by the CO_2 emission factor and the global warming potential.
- For the Base Year of 2006 through and including 2020, estimate total CH_4 emissions from Maryland power stations and cogenerators by multiplying total primary energy use by the CH_4 emission factor and the global warming potential.
- For the Base Year of 2005 through and including 2020, estimate total N_2O emissions from Maryland power stations and cogenerators by multiplying total primary energy use by the N_2O emission factor and the global warming potential.
- For the Base Year of 2005 through and including 2020, estimate total CO_2e emissions from Maryland power stations and cogenerators by adding the CO_2e of CO_2, CH_4, and N_2O.

Carbon dioxide-equivalent emissions from imported electricity. An overview of the methodology applied to forecast annual CO_2e emissions is briefly summarized below:

- For the Base Year of 2005 through and including 2020, estimate the average annual GHG emission intensity (i.e., metric tons of CO_2, CH_4, and N_2O per MWh of gross generation) for the MAAC/ECAR region from the data sources described earlier.
- For the Base Year of 2005 through and including 2020, estimate total CO_2 emissions associated with imported electricity by multiplying the gross generation associated with these imports by the CO_2 emission intensity and the global warming potential.
- For the Base Year of 2005 through and including 2020, estimate total CH_4 emissions associated with imported electricity by multiplying the gross generation associated with these imports by the CH_4 emission intensity and the global warming potential.

- For the Base Year of 2005 through and including 2020, estimate total N_2O emissions associated with imported electricity by multiplying the gross generation associated with these imports by the N_2O emission intensity and the global warming potential.
- For the Base Year of 2005 through and including 2020, estimate total CO_2e emissions associated with imported electricity by adding the CO_2e of CO_2, CH_4, and N_2O.

Greenhouse Gas Inventory Results

Figure A1 summarizes gross generation, primary energy use, and CO_2e emissions for Maryland power stations for the year 2005. Table A2 provides a summary of electric generating capacity for power plants located within the borders of Maryland, together with the CO_2 emissions from each unit for the period 2000 through the 2005 Base Year.

Figure A1. Breakdown of Maryland Generation, Capacity and CO_2e Emissions – 2005 Base Year

a. Gross Generation (53.1 TWh) **b. Energy (568 trillion btu)** **c. Emissions (34.0 MMtCO_2e)**

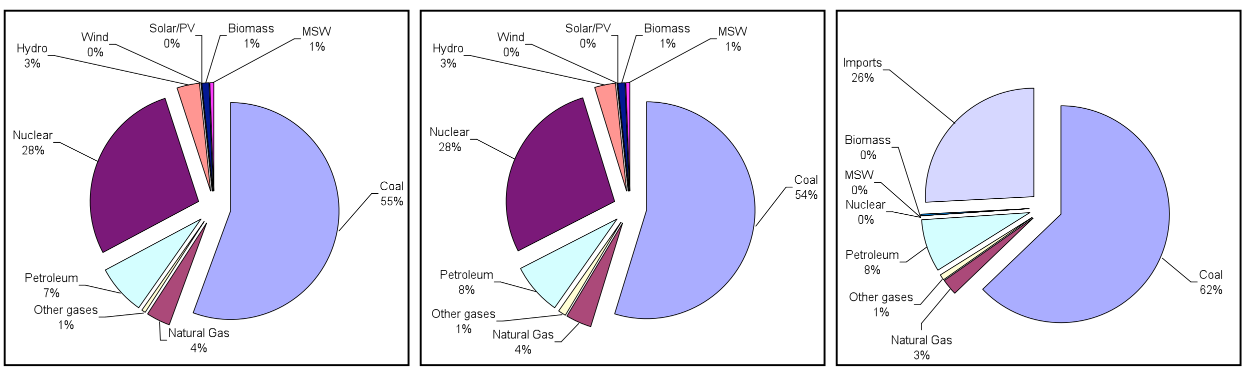


Table A2. Summary of Maryland Electric Generator and CO_2 Emission Characteristics from 2000 to the 2005 Base Year (source: http://www.rggi.org/docs/co2_2000_2006.xls)

Plant Name	Boiler ID	Generator ID	Nameplate Capacity (MW)	CO_2 Emissions (million short tons) 2000	2001	2002	2003	2004	2005
AES WARRIOR RUN COGEN	BLR1	GEN1	229	1.5	1.6	1.6	1.6	1.6	1.8
BRANDON SHORES	1	1	685	5.4	4.0	3.9	3.7	4.0	3.6
BRANDON SHORES	2	2	685	4.2	5.3	3.6	4.5	3.9	4.5
C P CRANE	1	1	190	1.2	1.0	1.4	1.2	1.1	1.1
C P CRANE	2	2	209	1.2	1.5	1.1	1.4	1.1	1.3
Chalk Point	GT3**		103	0.0	0.0	0.1	0.0	0.0	0.1
Chalk Point	GT4**		103	0.0	0.0	0.1	0.0	0.0	0.1
Chalk Point	GT5**		125	0.1	0.0	0.0	0.0	0.0	0.0
Chalk Point	GT6**		125	0.1	0.0	0.1	0.0	0.0	0.1
CHALK POINT	1	ST1	364	1.9	1.6	2.3	1.8	2.3	2.3
CHALK POINT	2	ST2	364	1.7	1.5	2.5	2.0	2.3	2.0
CHALK POINT	3	3	659	0.6	1.0	0.6	1.3	1.0	1.6
CHALK POINT	4	4	659	0.8	1.0	0.8	0.9	1.1	0.9
Chalk Point	GT2		35	0.0	0.0	0.0	0.0	0.0	0.0
Chalk Point	SMECO		90	0.0	0.0	0.0	0.0	0.0	0.0
DICKERSON	1	ST1	196	0.8	1.1	0.9	0.9	1.1	1.0
DICKERSON	2	2	196	1.2	1.1	1.0	0.8	1.1	1.2
DICKERSON	3	3	196	0.9	0.9	1.1	1.0	1.1	1.2
Dickerson	HCT1GT2		163	0.0	0.0	0.1	0.1	0.1	0.1
Dickerson	HCT2GT3		163	0.0	0.0	0.1	0.1	0.1	0.1
GOULD STREET	3	3	104	0.1	0.2	0.2	0.0	0.0	0.0
HERBERT A WAGNER	1	1	133	0.2	0.1	0.1	0.1	0.2	0.2
HERBERT A WAGNER	2	2	136	0.8	0.8	1.0	1.0	1.1	0.9
HERBERT A WAGNER	3	3	359	2.3	1.9	1.6	2.0	1.9	2.3
HERBERT A WAGNER	4	4	415	0.4	0.6	0.6	0.5	0.6	0.5
MORGANTOWN	1	ST1	626	3.8	3.3	4.0	3.8	3.1	2.9
MORGANTOWN	2	ST2	626	3.8	3.8	3.4	3.9	3.2	3.2
Morgantown	GT3		65	0.0	0.0	0.0	0.0	0.0	0.0
Morgantown	GT4		65	0.0	0.0	0.0	0.0	0.0	0.0
Morgantown	GT5		65	0.0	0.0	0.0	0.0	0.0	0.0
Morgantown	GT6		65	0.0	0.0	0.0	0.0	0.0	0.0
Panda Brandywine	1		99	0.2	0.1	0.0	0.0	0.0	0.0
Panda Brandywine	2		99	0.3	0.1	0.1	0.1	0.0	0.0
Panda Brandywine	3		91	0.0	0.0	0.0	0.0	0.0	0.0
Perryman	**51		192	0.1	0.1	0.0	0.0	0.1	0.0
Perryman	CT1		53	0.0	0.0	0.0	0.0	0.0	0.0
Perryman	CT2		53	0.0	0.0	0.0	0.0	0.0	0.0
Perryman	CT3		53	0.0	0.0	0.0	0.0	0.0	0.0
Perryman	CT4		53	0.0	0.0	0.0	0.0	0.0	0.0
R P SMITH	11	4	75	0.6	0.5	0.5	0.4	0.4	0.4
R P SMITH	9	3	35	0.1	0.1	0.1	0.1	0.1	0.1
Riverside	CT6		122	0.0	0.0	0.0	0.0	0.0	0.0

Riverside	4		72	0.0	0.0	0.0	0.0	0.0	0.0
VIENNA	8	8	162	0.3	0.2	0.3	0.1	0.1	0.1
Westport	CT5		122	0.0	0.0	0.0	0.0	0.0	0.0
Rock Springs Generating Facility	366		113	0.0	0.0	0.0	0.1	0.0	0.0
Rock Springs Generating Facility	367		113	0.0	0.0	0.0	0.0	0.0	0.0
Rock Springs Generating Facility	368		227	0.0	0.0	0.0	0.0	0.0	0.1
Rock Springs Generating Facility	369		227	0.0	0.0	0.0	0.0	0.0	0.1
Luke				1.0	1.0	1.1	1.1	1.1	1.1
Mittal				2.6	2.4	2.7	2.1	2.3	2.1
Total			**10,158.5**	**38.4**	**37.0**	**37.1**	**37.1**	**36.3**	**37.3**

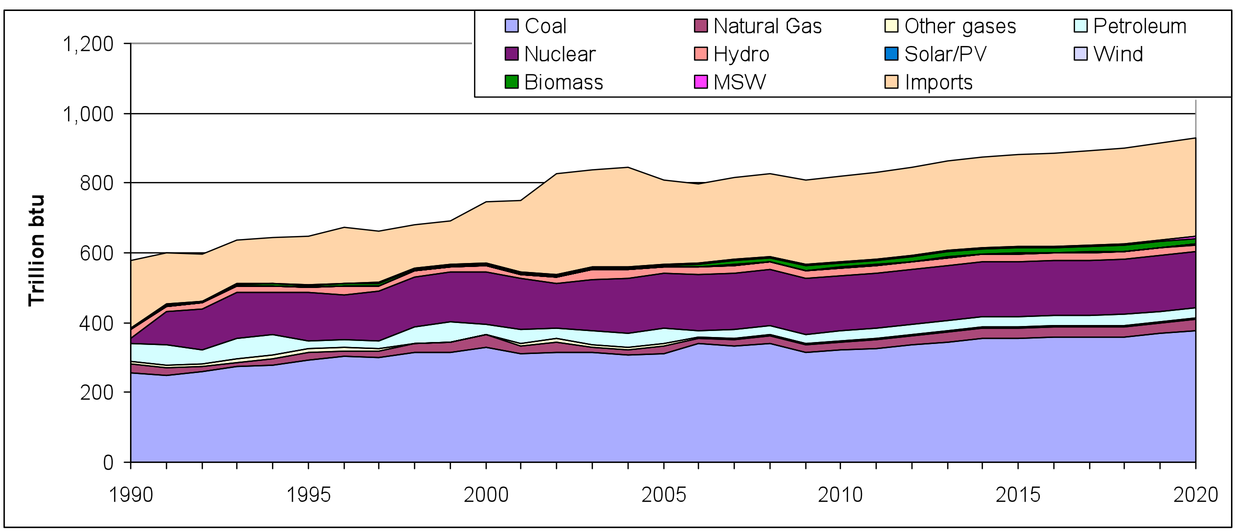
Greenhouse Gas Forecast Results

The following subsections provide an overview of the results obtained after applying the methodological approach described above.

Primary Energy Consumption

Total primary energy consumption associated with electricity generation in Maryland is summarized in Figure A2 for the Reference Case. Primary energy consumption in Maryland is dominated by coal and nuclear resources.

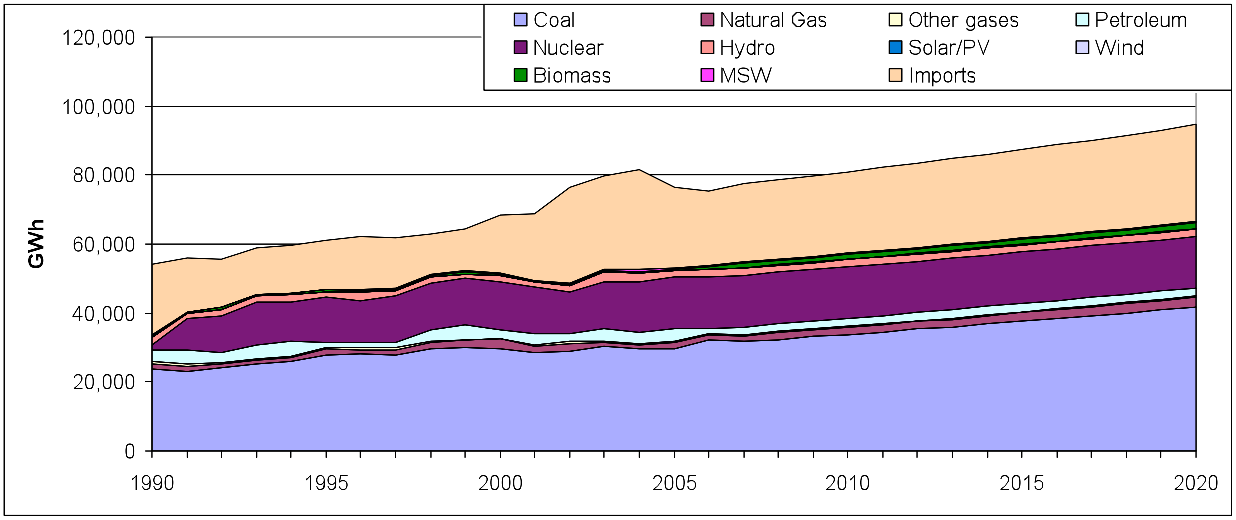
Figure A2. Primary Energy Use at Maryland Power Stations, plus imports



Gross Generation

Total gross generation by Maryland power plants is summarized in Figure A3 for the Reference Case. Gross generation in Maryland is dominated by steam units, which are primarily based on coal and nuclear fuel.

Figure A3. Gross Generation at Maryland Power Stations, plus imports



Total Emissions

Total emissions associated with generation by Maryland power plants as well as emissions from generation by power plants located outside Maryland to meet electricity demand within Maryland are summarized in Figure A4 and in Table A3 for the Reference Case. On a consumption basis, emissions reach 54.8 $MMtCO_2e$ in 2020.

Figure A4. Total Emissions Associated with Electric Demand in Maryland ($MMtCO_2e$)

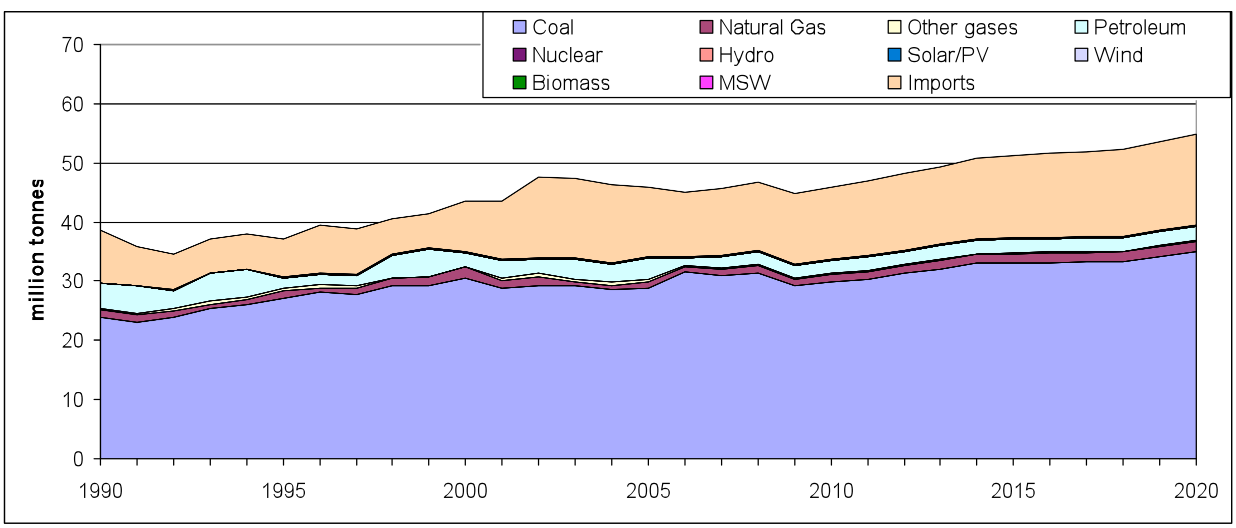
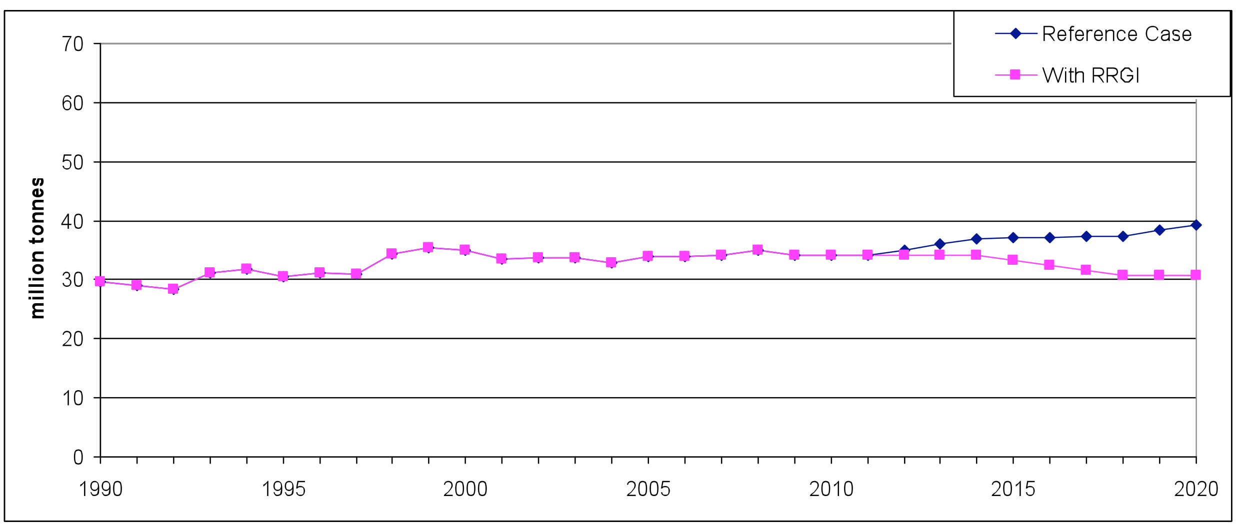


Table A3. Consumption-Based GHG Emissions from Electricity Supply in Maryland ($MMtCO_2e$)

Fuel	1990	1995	2000	2005	2010	2015	2020
Coal	23.89	27.02	30.48	28.80	30.35	33.06	35.04
Natural Gas	1.29	1.27	1.93	1.18	1.31	1.54	1.74
Other Gases	0.31	0.59	0.05	0.35	0.18	0.19	0.20
Petroleum	4.22	1.69	2.42	3.52	2.19	2.28	2.35
Biomass	0.003	0.003	0.003	0.004	0.01	0.01	0.01
MSW	0.03	0.11	0.21	0.19	0.20	0.22	0.22
Imports	8.83	6.51	8.55	11.82	12.27	13.83	15.25
Total (Consumption-based)	**38.58**	**37.19**	**43.64**	**45.86**	**46.52**	**51.13**	**54.82**

Total CO_2 emissions associated with generation by Maryland power plants, with and without the participation of Maryland in the Regional Greenhouse Gas Initiative (RGGI), are summarized in Figure A5. The Maryland CO_2 cap is set at 34.1 $MMtCO_2$ (37.5 million short tons) from 2009 through 2014, declines to 30.6 $MMtCO_2$ (33.8 million short tons) by 2018, and remains at this level through 2020. The CO_2 emission reductions from the RGGI cap are 8.7 $MMtCO_2$ (9.6 million short tons) in 2020. Cumulative CO_2 emission reductions through 2020 from the RGGI CO_2 cap are 44.1 $MMtCO_2$ (48.5 million short tons).

Figure A5. Total Emissions Associated with Electricity Production in Maryland, with and without the RGGI CO_2 cap ($MMtCO_2$)



Appendix B. Residential, Commercial, and Industrial (RCI) Fuel Combustion

Overview

Activities in the RCI[22] sectors produce carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O) emissions when fuels are combusted to provide space heating, water heating, process heating, cooking, and other energy end-uses. Carbon dioxide accounts for over 99% of these emissions on a million metric tons (MMt) of CO_2 equivalent (CO_2e) basis in Maryland. In addition, since these sectors consume electricity, one can also attribute emissions associated with electricity generation to these sectors in proportion to their electricity use.[23] Direct use of oil, natural gas, coal, and wood in the RCI sectors accounted for an estimated 20 $MMtCO_2e$ of gross greenhouse gas (GHG) emissions in 2005.[24]

Emissions and Reference Case Projections

Emissions from direct fuel use were estimated using the United States Environmental Protection Agency's (US EPA) State Greenhouse Gas Inventory Tool (SIT) software and the methods provided in the Emission Inventory Improvement Program (EIIP) guidance document for RCI fossil and wood fuel combustion.[25] The default data used in SIT for Maryland are from the United States Department of Energy (US DOE) Energy Information Administration's (EIA) *State Energy Data* (SED). The SIT files were updated to include 2004 and 2005 SED information for Maryland for natural gas, petroleum, coal, and wood for each of the RCI sectors.[26]

Note that the EIIP methods for the industrial sector exclude from CO_2 emission estimates the amount of carbon that is stored in products produced from fossil fuels for non-energy uses. For example, the methods account for carbon stored in petrochemical feedstocks, and in liquefied petroleum gases (LPG) and natural gas used as feedstocks by chemical manufacturing plants

[22] The industrial sector includes emissions associated with agricultural energy and natural gas consumed as lease and plant fuel. Emissions associated with pipeline fuel use are included in Appendix E.

[23] Emissions associated with the electricity supply sector (presented in Appendix A) have been allocated to each of the RCI sectors for comparison of those emissions to the fuel-consumption-based emissions presented in Appendix B. Note that this comparison is provided for information purposes and that emissions estimated for the electricity supply sector are not double-counted in the total emissions for the state. One could similarly allocate GHG emissions from natural gas T&D, other fuels production, and transport-related GHG sources to the RCI sectors based on their direct use of gas and other fuels, but we have not done so here due to the difficulty of ascribing these emissions to particular end-users. Estimates of emissions associated with the transportation sector are provided in Appendix C, and estimates of emissions associated with natural gas T&D are provided in Appendix E.

[24] Emissions estimates from wood combustion include only N_2O and CH_4. Carbon dioxide emissions from biomass combustion are assumed to be "net zero", consistent with US EPA and Intergovernmental Panel on Climate Change (IPCC) methodologies, and any net loss of carbon stocks due to biomass fuel use should be accounted for in the land use and forestry analysis.

[25] GHG emissions were calculated using SIT, with reference to *EIIP, Volume VIII*: Chapter 1 "Methods for Estimating Carbon Dioxide Emissions from Combustion of Fossil Fuels", August 2004, and Chapter 2 "Methods for Estimating Methane and Nitrous Oxide Emissions from Stationary Combustion", August 2004.

[26] EIA *State Energy Data through 2005 (*http://www.eia.doe.gov/emeu/states/_seds_updates.html).

(i.e., not used as fuel), as well as carbon stored in asphalt and road oil produced from petroleum. The carbon storage assumptions for these products are explained in detail in the EIIP guidance document.[27] The fossil fuel types for which the EIIP methods are applied in the SIT software to account for carbon storage include the following categories: asphalt and road oil, coking coal, distillate fuel, feedstocks (naphtha with a boiling range of less than 401 degrees Fahrenheit), feedstocks (other oils with boiling ranges greater than 401 degrees Fahrenheit), LPG, lubricants, miscellaneous petroleum products, natural gas, pentanes plus,[28] petroleum coke, residual fuel, still gas, and waxes. Data on annual consumption of the fuels in these categories as chemical industry feedstocks were obtained from the EIA SED.

Table B1 shows historic and projected growth rates for electricity sales by sector. For 2005 to 2020, the annual growth rates are based on AEO2007 regional, sector-level forecasts prepared by the EIA using the National Energy Modeling System (NEMS) for the Mid-Atlantic Area Council (MAAC) region that includes Maryland. These annual growth rates were used to forecast electricity sales from 2005 to 2020 for each sector. The proportion of each RCI sector's sales to total sales was used to allocate emissions associated with the electricity supply sector to each of the RCI sectors. Note that the proportion of commercial electricity sales increased and the proportion of industrial electricity sales decreased by about the same amount from 1995 through 2001, and then in 2002 the proportions changed to those observed from 1990 to 2004. These proportional changes are believed to be associated with how utilities reported customer sales rather than with real changes in electricity demand (sales) for these sectors.

Table B2 shows historic and projected growth rates for energy use by sector and fuel type. Reference case emissions from direct fuel combustion were estimated based on fuel consumption forecasts from EIA's *Annual Energy Outlook 2006* (AEO2006).[29] For the RCI sectors, annual growth rates for natural gas, oil, wood, and coal were calculated from the AEO2006 regional forecast that EIA prepared for the South Atlantic modeling region. For the residential sector, the AEO2006 annual growth rate in fuel consumption from 2005 through 2020 was normalized using the AEO2006 population forecast and then weighted using Maryland's population forecast over this period.[30] Maryland's rate of population growth is expected to average about 0.86% annually between 2005 and 2020.[31] The AEO2006 estimates of growth in regional fuel consumption reflect expected responses of the economy — as simulated by the EIA's National Energy Modeling System — to changing fuel and electricity prices and changing technologies, as well as to structural changes within each sector (such as shifts in subsectoral shares and in energy use patterns).

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[27] EIIP, Volume VIII: Chapter 1 "Methods for Estimating Carbon Dioxide Emissions from Combustion of Fossil Fuels", August 2004.
[28] A mixture of hydrocarbons, mostly pentanes and heavier fractions, extracted from natural gas.
[29] EIA AEO2006 with Projections to 2030 (http://www.eia.doe.gov/oiaf/archive.html#aeo).
[30] AEO2006 population and employment projections for EIA's South Atlantic region obtained through special request from EIA (dated September 27, 2006).
[31] Maryland Department of Planning, Planning Data Services. Population data for 1990, 2000, and estimated 2006, 2010, 2020, and 2030 downloaded from http://www.msa.md.gov/msa/mdmanual/01glance/html/pop.html#state.

Table B1. Electricity Sales Annual Growth Rates, Historical and Projected

Sector	1990-2005*	2005-2020**
Residential	2.69%	1.34%
Commercial	3.23%	1.81%
Industrial	0.72%	0.23%
Total	**2.12%**	**1.14%**

* 1990-2005 compound annual growth rates calculated from Maryland electricity sales by year from EIA State Electricity Profiles (Table 8) (http://www.eia.doe.gov/cneaf/electricity/st_profiles/e_profiles_sum.html).

** 2005-2020 compound annual growth rates based on AEO2007 regional, sector-level forecasts prepared by the EIA using the National Energy Modeling System (NEMS) (a model that forecasts electric expansion/electricity demand in the USA) for the Mid-Atlantic Area Council (MAAC) region that includes Maryland.

Table B2. Historical and Projected Average Annual Growth in Energy Use in Maryland, by Sector and Fuel, 1990-2020

	1990-2005[a]	2005-2010[b]	2010-2015[b]	2015-2020[b]
Residential				
natural gas	1.9%	2.0%	1.3%	1.1%
petroleum	-0.2%	-1.2%	-0.8%	-1.3%
wood	-1.2%	-0.3%	-1.0%	-0.5%
coal	-7.9%	-0.3%	-1.6%	-1.6%
Commercial				
natural gas	7.5%	-0.7%	0.9%	0.02%
petroleum	-2.8%	-2.8%	-0.8%	-1.4%
wood	2.1%	-2.2%	-1.7%	-2.0%
coal	-2.0%	-2.3%	-1.7%	-2.0%
Industrial				
natural gas	-6.1%	1.9%	0.8%	0.3%
petroleum	0.9%	-0.8%	-0.01%	0.3%
wood	0.8%	1.5%	0.9%	0.7%
coal	-3.6%	0.2%	0.04%	-0.1%

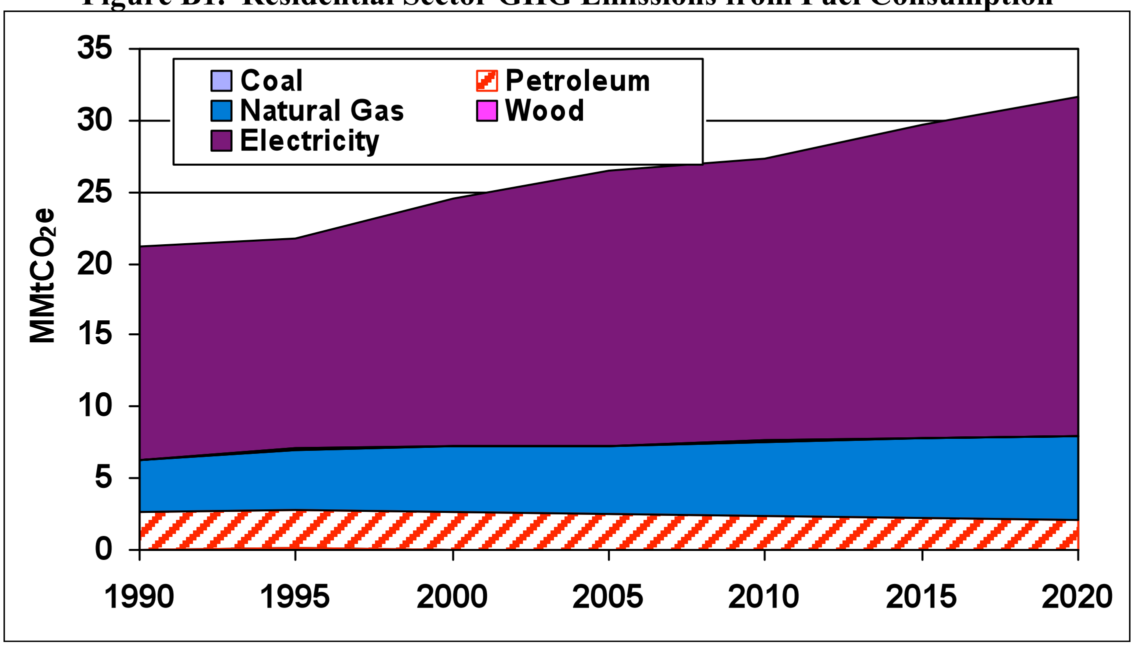
[a] Compound annual growth rates calculated from EIA SED historical consumption by sector and fuel type for Maryland. Latest year for which EIA SED information was available for all fuel types was 2005. Petroleum includes distillate fuel, kerosene, and liquefied petroleum gases for all sectors plus residual oil for the commercial and industrial sectors.
[b] Figures for growth periods starting after 2005 are calculated from AEO2006 projections for EIA's South Atlantic region. Regional growth rates for the residential sector are adjusted for Maryland's projected population.

Results

Figures B1, B2, and B3 show historical and projected emissions for the RCI sectors in Maryland from 1990 through 2020. These figures show the emissions associated with the direct consumption of fossil fuels and, for comparison purposes, show the share of emissions associated with the generation of electricity consumed by each sector. During the period from 1990 through 2020, the residential sector's share of total RCI emissions from direct fuel use and electricity was 35% in 1990, increased to 40% in 2005, and is projected to increase further to 42% in 2020. The commercial sector's share of total RCI emissions from direct fuel use and electricity use was 19% in 1990, increased to 26% in 2005, and is projected to increase slightly to 27% by 2020. The industrial sector's share of total RCI emissions from direct fuel use and electricity use was 45% in 1990, decreased to 34% in 2005, and is projected to decrease further to 31% in 2020. Emissions associated with the generation of electricity to meet RCI demand accounts for about 72% of the emissions for the residential sector, 75% of the emissions for the commercial sector, and 59% of the emissions for the industrial sector, on average, over the 1990 to 2020 time period. From 1990 to 2020, natural gas consumption is the next highest source of emissions for the residential and commercial sectors, accounting, on average, for about 18% and 19% of total emissions, respectively. For the industrial sector, emissions associated with the combustion of coal, natural gas, and petroleum account for about 15%, 10%, and 16% respectively, on average, from 1990 to 2020.

Residential Sector
Figure B1 presents the emission inventory and reference case projections for the residential sector. Figure B1 was developed from the emissions data in Table B3a. Table B3b shows the relative contributions of emissions associated with each fuel type to total residential sector emissions.

Figure B1. Residential Sector GHG Emissions from Fuel Consumption



Source: CCS calculations based on approach described in text.
Note: Emissions associated with coal and wood combustion are too small to be seen on this graph.

For the residential sector, emissions from electricity and direct fossil fuel use in 1990 were about 21.2 MMtCO_2e, and are estimated to increase to about 31.6 MMtCO_2e by 2020. Emissions associated with the generation of electricity to meet residential energy consumption demand accounted for about 70% of total residential emissions in 1990, and are estimated to increase to 75% of total residential emissions by 2020. In 1990, natural gas consumption accounted for about 17% of total residential emissions, and is estimated to account for about 19% of total residential emissions by 2020. Residential-sector emissions associated with the use of coal, petroleum, and wood in 1990 were about 2.7 MMtCO_2e combined, and accounted for about 13%

of total residential emissions. By 2020, emissions associated with the consumption of these three fuels are estimated to fall to 2.1 $MMtCO_2e$, accounting for about 7% of total residential sector emissions by that year.

For the 15-year period 2005 to 2020, residential-sector GHG emissions associated with the use of electricity and natural gas are both expected to increase at average annual rates of about 1.4%. Emissions associated with the use of petroleum, wood, and coal are expected to decline annually by about -1.1%, -0.6%, and -1.3%, respectively. Total GHG emissions for this sector increase by an average of about 1.2% annually over the 15-year period.

Table B3a. Residential Sector Emissions Inventory and Reference Case Projections ($MMtCO_2e$)

Fuel Type	1990	1995	2000	2005	2010	2015	2020
Coal	0.02	0.10	0.02	0.01	0.01	0.01	0.01
Petroleum	2.59	2.71	2.60	2.47	2.33	2.23	2.08
Natural Gas	3.63	4.17	4.61	4.78	5.23	5.56	5.84
Wood	0.06	0.08	0.07	0.05	0.05	0.04	0.04
Electricity Consumption	14.88	14.73	17.22	19.21	19.70	21.87	23.66
Total	21.17	21.78	24.53	26.51	27.32	29.72	31.63

Source: CCS calculations based on approach described in text.

Table B3b. Residential Sector Proportions of Total Emissions by Fuel Type (%)

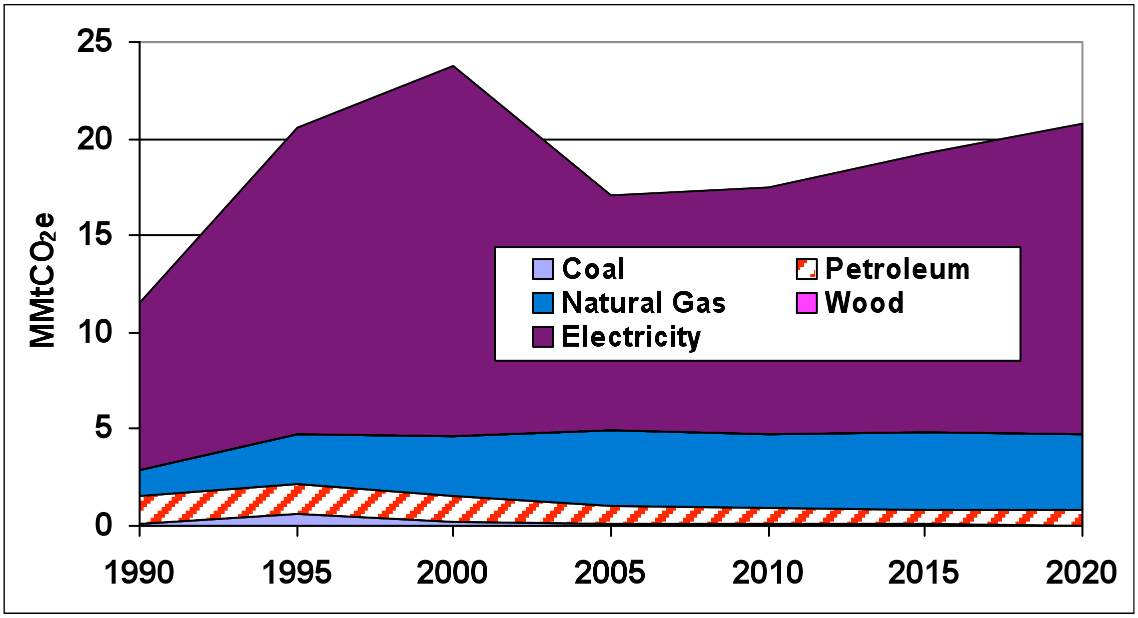
Fuel Type	1990	1995	2000	2005	2010	2015	2020
Coal	0.1%	0.4%	0.1%	0.03%	0.03%	0.02%	0.02%
Petroleum	12.2%	12.4%	10.6%	9.3%	8.5%	7.5%	6.6%
Natural Gas	17.1%	19.1%	18.8%	18.0%	19.2%	18.7%	18.5%
Wood	0.3%	0.4%	0.3%	0.2%	0.2%	0.1%	0.1%
Electricity Consumption	70.3%	67.6%	70.2%	72.5%	72.1%	73.6%	74.8%

Source: CCS calculations based on approach described in text.
Note: The percentages shown in this table reflect the emissions for each fuel type as a percentage of total emissions shown in Table B3a.

Commercial Sector
Figure B2 presents the emission inventory and reference case projections for the commercial sector. Figure B2 was developed from the emissions data in Table B4a. Table B4b show the relative contributions of emissions associated with each fuel type to total commercial sector emissions.

For the commercial sector, emissions from electricity and direct fossil fuel use in 1990 were about 11.6 $MMtCO_2e$, and are estimated to increase to about 20.8 $MMtCO_2e$ by 2020. Emissions associated with the generation of electricity to meet commercial energy consumption demand accounted for about 75% of total commercial emissions in 1990, and are estimated to increase to 77% of total commercial emissions by 2020. In 1990, natural gas consumption accounted for about 11% of total commercial emissions and is estimated to account for about 19% of total commercial emissions by 2020. Emissions associated with the consumption of petroleum accounted for about 13% of total commercial emissions in 1990, but are estimated to account for only 4% of total emissions by 2020. Commercial-sector emissions associated with the use of coal and wood in 1990 were about 0.1 $MMtCO_2e$ combined, and accounted for about 1% of total commercial emissions. By 2020, emissions associated with the consumption of these two fuels are estimated to be 0.06 $MMtCO_2e$ and to account for 0.3% of total commercial sector emissions.

Figure B2. Commercial Sector GHG Emissions from Fuel Consumption



Source: CCS calculations based on approach described in text.
Note: Emissions associated with wood combustion are too small to be seen on this graph.

Table B4a. Commercial Sector Emissions Inventory and Reference Case Projections ($MMtCO_2e$)

Fuel Type	1990	1995	2000	2005	2010	2015	2020
Coal	0.09	0.61	0.18	0.07	0.06	0.06	0.05
Petroleum	1.49	1.55	1.40	0.96	0.85	0.81	0.76
Natural Gas	1.31	2.55	3.06	3.88	3.81	3.96	3.96
Wood	0.01	0.02	0.01	0.01	0.01	0.01	0.01
Electricity Consumption	8.66	15.81	19.17	12.11	12.71	14.44	15.98
Total	11.57	20.54	23.82	17.03	17.44	19.27	20.76

Source: CCS calculations based on approach described in text.

For the 15-year period from 2005 to 2020, commercial-sector GHG emissions associated with the use of electricity and natural gas are expected to increase at average annual rates of about 1.9% and 0.13%, respectively. Emissions associated with the use of petroleum, wood, and coal are expected to decline annually by about -1.5%, -1.9%, and -2.0%, respectively. Total GHG emissions for this sector increase by an average of about 1.3% annually over the 15-year period.

Table B4b. Commercial Sector Proportions of Total Emissions by Fuel Type (%)

Fuel Type	1990	1995	2000	2005	2010	2015	2020
Coal	0.8%	3.0%	0.7%	0.4%	0.3%	0.3%	0.2%
Petroleum	12.9%	7.5%	5.9%	5.6%	4.9%	4.2%	3.7%
Natural Gas	11.4%	12.4%	12.8%	22.8%	21.8%	20.5%	19.1%
Wood	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.05%
Electricity Consumption	74.9%	77.0%	80.5%	71.1%	72.9%	74.9%	77%

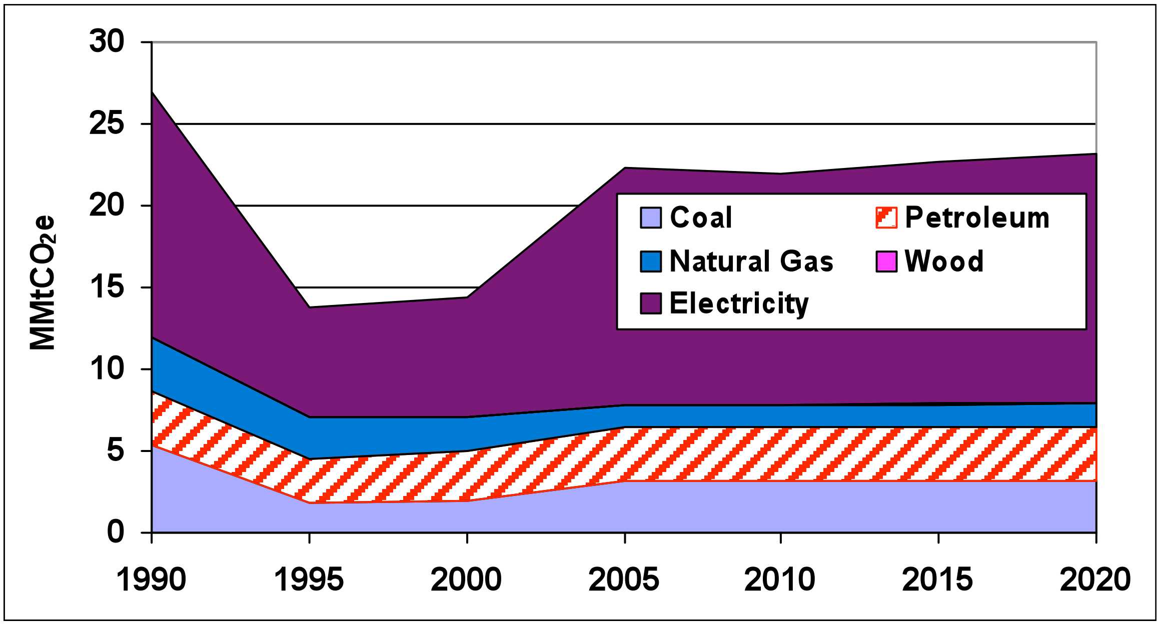
Source: CCS calculations based on approach described in text.
Note: The percentages shown in this table reflect the emissions for each fuel type as a percentage of total emissions shown in Table B4a.

Industrial Sector
Figure B3 presents the emission inventory and reference case projections for the industrial sector. Figure B3 was developed from the emissions data in Table B5a. Table B5b show the relative contributions of emissions associated with each fuel type to total industrial sector emissions.

For the industrial sector, emissions from electricity and direct fuel use in 1990 were about 27.0 $MMtCO_2e$ and are estimated to decline to about 23.1 $MMtCO_2e$ by 2020. Emissions associated with the generation of electricity to meet industrial energy consumption demand accounted for about 56% of total industrial emissions in 1990, and are estimated increase to about 66% of total industrial emissions by 2020. In 1990, natural gas consumption accounted for about 12% of total industrial emissions, and is estimated to account for about 6% of total industrial emissions by 2020. Emissions associated with the consumption of petroleum accounted for about 12% of total industrial emissions in 1990, but are estimated to increase slightly to account for about 14% of total emissions by 2020. Industrial-sector emissions associated with the use of coal and wood in 1990 were about 5.4 $MMtCO_2e$ combined, and accounted for about 20% of total industrial emissions. For 2020, emissions associated with the consumption of coal and wood are estimated to decrease to 3.2 $MMtCO_2e$, and to account for 14% of total industrial sector emissions. Note that industrial-sector emissions associated with the use of wood from 1990 to 2020 are negligible.

For the 15-year period 2005 to 2020, industrial-sector GHG emissions associated with the use of electricity, natural gas, coal, and wood are expected to increase at average annual rates of about 0.29%, 0.90%, 0.04%, and 1.0%, respectively. Emissions associated with the use of petroleum are expected to decrease annually by about -0.08%. Total GHG emissions for the industrial sector increase by an average of about 0.24% annually over the 15-year period.

Figure B3. Industrial Sector GHG Emissions from Fuel Consumption



Source: CCS calculations based on approach described in text.
Note: Emissions associated with wood combustion are too small to be seen on this graph.

Table B5a. Industrial Sector Emissions Inventory and Reference Case Projections ($MMtCO_2e$)

Fuel Type	1990	1995	2000	2005	2010	2015	2020
Coal	5.42	1.83	1.93	3.14	3.16	3.16	3.16
Petroleum	3.19	2.63	3.04	3.36	3.25	3.26	3.32
Natural Gas	3.31	2.61	2.13	1.28	1.39	1.44	1.47
Wood	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Electricity Consumption	15.04	6.66	7.24	14.53	14.11	14.82	15.17
Total	26.97	13.75	14.37	22.34	21.94	22.71	23.14

Source: CCS calculations based on approach described in text.

Table B5b. Industrial Sector Proportions of Total Emissions by Fuel Type (%)

Fuel Type	1990	1995	2000	2005	2010	2015	2020
Coal	20.1%	13.3%	13.5%	14.1%	14.4%	13.9%	13.6%
Petroleum	11.8%	19.1%	21.2%	15.1%	14.8%	14.4%	14.4%
Natural Gas	12.3%	19.0%	14.9%	5.7%	6.3%	6.3%	6.3%
Wood	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%
Electricity Consumption	56%	48.4%	50.4%	65.1%	64.3%	65.3%	65.6%

Source: CCS calculations based on approach described in text.
Note: The percentages shown in this table reflect the emissions for each fuel type as a percentage of total emissions shown in Table B5a.

Key Uncertainties

Key sources of uncertainty underlying the estimates above are as follows:

- Population and economic growth are the principal drivers for electricity and fuel use. The reference case projections are based on regional fuel consumption projections for EIA's South Atlantic modeling region. Consequently, there are significant uncertainties associated with the projections. Future work should attempt to base projections of GHG emissions on fuel consumption estimates specific to Maryland to the extent that such data become available.
- The AEO2006 projections assume no large long-term changes in relative fuel and electricity prices, relative to current price levels and to US DOE projections for fuel prices. Price changes would influence consumption levels and, to the extent that price trends for competing fuels differ, may encourage switching among fuels, and thereby affect emissions estimates.

Appendix C. Transportation Energy Use

Overview

Transportation is one the largest greenhouse gas (GHG) source sectors in Maryland. The transportation sector includes light- and heavy-duty onroad vehicles, aircraft, rail engines, and marine engines. Carbon dioxide (CO_2) accounted for about 97% of the transportation sector's GHG emissions in 1990 and is projected to increase to about 98% of transportation GHG emissions by 2020. Most of the remaining GHG emissions from the transportation sector are due to nitrous oxide (N_2O) emissions from gasoline engines.

Historical Emissions and Reference Case Projections

Historical greenhouse gas emissions were estimated using the United States Environmental Protection Agency's (US EPA) State Greenhouse Gas Inventory Tool (SIT) software and the methods provided in the Emission Inventory Improvement Program (EIIP) guidance document for the sector.[32,33] For on-road vehicles, the CO_2 emission factors are in units of pounds (lb) per million British thermal unit (MMBtu) and the methane (CH_4) and N_2O emission factors are both in units of grams per vehicle mile traveled (VMT). Key assumptions in this analysis are listed in Table C1. The default fuel consumption data within SIT were used to estimate emissions, with the most recently fuel consumption data (2004), available at the time of the calculations, from the United States Department of Energy (US DOE) Energy Information Administration's (EIA) *State Energy Data* (SED) added.[34] The default VMT data in SIT were replaced with annual VMT from the Maryland Department of the Environment (MDE).[35] Default data from the Federal Highway Administration (FHWA)[36] were used to allocate the VMT by vehicle type in the state.

Onroad Vehicles

Onroad vehicle gasoline and diesel CH_4 and N_2O emissions were projected based on VMT forecasts from MDE and growth rates developed from national vehicle type VMT forecasts reported in EIA's *Annual Energy Outlook* 2006 (AEO2006). The AEO2006 data were incorporated because they indicate significantly different VMT growth rates for certain vehicle types (e.g., 20% growth between 2005 and 2020 in light-duty gasoline vehicle VMT versus 44% growth in heavy-duty diesel truck VMT over this period). The procedure first applied the AEO2006 vehicle type-based national growth rates to 2005 estimates of VMT by vehicle type in Maryland. These data were then used to calculate the estimated proportion of total VMT by vehicle type in each year. Next, these proportions were applied to the MDE estimates for total VMT in the state for each year to yield the vehicle type VMT estimates and compound annual

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[32] CO_2 emissions were calculated using SIT, with reference to Emission Inventory Improvement Program, Volume VIII: Chapter. 1. "Methods for Estimating Carbon Dioxide Emissions from Combustion of Fossil Fuels", August 2004.

[33] CH_4 and N_2O emissions were calculated using SIT, with reference to Emission Inventory Improvement Program, Volume VIII: Chapter. 3. "Methods for Estimating Methane and Nitrous Oxide Emissions from Mobile Combustion", August 2004.

[34] Energy Information Administration, State Energy Consumption, Price, and Expenditure Estimates (SED), http://www.eia.doe.gov/emeu/states/_seds.html

[35] Maryland VMT forecast data provided by Mohamed Khan, Maryland Department of the Environment

[36] Highway Statistics, Federal Highway Administration, http://www.fhwa.dot.gov/policy/ohpi/hss/index.htm.

average growth rates which are displayed in Tables C2 and C3, respectively. The VMT growth rates from gasoline vehicles were also applied to natural gas vehicles.

Table C1. Key Assumptions and Methods for the Transportation Inventory and Projections

Vehicle Type and Pollutants	Methods
Onroad gasoline, diesel, natural gas, and liquefied petroleum gas (LPG) vehicles – CO_2	**Inventory (1990 – 2004)** US EPA SIT and fuel consumption from EIA State Energy Data (SED) **Reference Case Projections (2005 – 2020)** Gasoline and diesel fuel projected using VMT projections provided by MDE adjusted by fuel efficiency improvement projections from AEO2006. Other onroad fuels projected using South Atlantic Region fuel consumption projections from EIA AEO2006 adjusted using state-to-regional ratio of population growth.
Onroad gasoline and diesel vehicles – CH_4 and N_2O	**Inventory (1990 – 2005)** US EPA SIT, onroad vehicle CH_4 and N_2O emission factors by vehicle type and technology type within SIT were updated to the latest factors used in the US EPA's *Inventory of US Greenhouse Gas Emissions and Sinks: 1990-2005.* State total VMT replaced with VMT provided by MDE, VMT allocated to vehicle types using default data in SIT. **Reference Case Projections (2006 – 2020)** VMT projections from MDE allocated to vehicle types using vehicle specific growth rates from AEO2006.
Non-highway fuel consumption (jet aircraft, gasoline-fueled piston aircraft, boats, locomotives) – CO_2, CH_4 and N_2O	**Inventory (1990 – 2004)** US EPA SIT and fuel consumption from EIA SED. Commercial marine based on allocation of national fuel consumption, offshore emissions pulled from Commission for Environmental Cooperation in North America (CEC) inventory. **Reference Case Projections (2005 – 2020)** Aircraft projected using aircraft operations projections from Federal Aviation Administration (FAA). No growth assumed for rail diesel. Marine fuels projected based on linear regression of historical data.

Table C2. Maryland Vehicle Miles Traveled Estimates (millions)

Vehicle Type	2002	2005	2010	2015	2020
Heavy-Duty Diesel Vehicle	3,634	3,795	4,402	5,027	5,694
Heavy-Duty Gasoline Vehicle	533	560	603	671	744
Light-Duty Diesel Truck	531	574	788	1,081	1,489
Light Duty-Diesel Vehicle	165	172	237	325	447
Light-Duty Gasoline Truck	17,657	19,079	20,629	22,269	23,836
Light-Duty Gasoline Vehicle	31,058	32,351	34,981	37,760	40,418
Motorcycle	180	194	209	226	242
Total	53,759	56,725	61,849	67,359	72,870

Table C3. Maryland Vehicle Miles Traveled Compound Annual Growth Rates

Vehicle Type	2002-2005	2005-2010	2010-2015	2015-2020
Heavy-Duty Diesel Vehicle	1.45%	3.01%	2.69%	2.52%
Heavy-Duty Gasoline Vehicle	1.64%	1.49%	2.15%	2.09%
Light-Duty Diesel Truck	2.61%	6.55%	6.53%	6.61%
Light-Duty Diesel Vehicle	1.37%	6.55%	6.53%	6.61%
Light-Duty Gasoline Truck	2.61%	1.58%	1.54%	1.37%
Light-Duty Gasoline Vehicle	1.37%	1.58%	1.54%	1.37%
Motorcycle	2.50%	1.58%	1.54%	1.37%

For forecasting CO_2 emissions, growth in fuel consumption is also needed along with VMT. Onroad gasoline and diesel fuel consumption were forecasted by developing a set of growth factors that adjusted the VMT projections to account for expected improvements in fuel efficiency. Fuel efficiency projections were taken from EPA. The resulting onroad fuel consumption growth rates are shown in Table C4. Growth rates for projecting CO_2 emissions from natural gas vehicles, lubricants, and other fuel consumption were calculated by allocating the AEO2006 consumption of these fuels in the South Atlantic region to Maryland based on the ratio of the state's projected population to the region's projected population.

Table C4. Maryland Onroad Fuel Consumption Compound Annual Growth Rates

Fuel Growth Factors	2002-2005	2005-2010	2010-2015	2015-2020
Onroad diesel	1.32%	2.98%	3.02%	2.87%
Onroad gasoline	1.83%	1.10%	1.28%	1.31%

Gasoline consumption estimates for 1990-2004 were adjusted by subtracting ethanol consumption, per the methodology used in SIT. The historical EIA ethanol consumption data show that use of ethanol in Maryland began in 1995, peaked in 2002, and dropped off considerably in 2003 and 2004, with ethanol consumption ranging from less than 0.01% to

0.77% of the gasoline consumption on a Btu basis. For the reference case projections, ethanol consumption was assumed to remain at the 2004 level.

Aviation

For the aircraft sector, emission estimates for 1990 to 2004 are based on SIT methods and fuel consumption from EIA. Emissions were projected from 2005 to 2020 using general aviation and commercial aircraft operations for Maryland from 2005 through 2020 from the Federal Aviation Administration's (FAA) Terminal Area Forecast System[37] and national aircraft fuel efficiency forecasts. To estimate changes in jet fuel consumption, itinerant aircraft operations from air carrier, air taxi/commuter, and military aircraft were first summed for each year of interest. The post-2004 estimates were adjusted to reflect the projected increase in national aircraft fuel efficiency (indicated by increased number of seat miles per gallon), as reported in AEO2006. Because AEO2006 does not estimate fuel efficiency changes for general aviation aircraft, forecast changes in aviation gasoline consumption were based solely on the projected number of itinerant general aviation aircraft operations in Maryland, which was obtained from the FAA. The resulting compound annual average growth rates are displayed in Table C5.

Table C5. Maryland Aviation Fuels Compound Annual Growth Rates

Fuel	2002-2005	2005-2010	2010-2015	2015-2020
Aviation Gasoline	3.64%	0.08%	0.50%	0.41%
Jet Fuel	1.02%	0.15%	0.75%	0.70%

Rail and Marine Vehicles

For the rail and recreational marine (gasoline fuel) sectors, 1990 to 2004 estimates are based on SIT methods and fuel consumption from EIA. Marine gasoline consumption was projected to 2020 based on a linear regression of the 1990 through 2004 historical Maryland fuel consumption data. The historic data for rail shows no significant positive or negative trend; therefore, no growth was assumed for this sector.

For the commercial marine sector (marine diesel and residual fuel), 1990-2004 emission estimates are based on SIT emission rates applied to estimates of Maryland marine vessel diesel and residual fuel consumption. Because the SIT default relies on marine vessel fuel consumption estimates that represent the state in which fuel is sold rather than consumed, an alternative method was used to estimate Maryland marine vessel fuel consumption. Maryland fuel consumption estimates were developed by allocating 1990-2004 national diesel and residual oil vessel bunkering fuel consumption estimates obtained from EIA[38] after subtracting out the portion of national marine fuel consumed during international transport.[39] Marine vessel fuel consumption was allocated to Maryland using the marine vessel activity allocation methods/data

[37] Terminal Area Forecast, Federal Aviation Administration, http://www.apo.data.faa.gov/main/taf.asp.
[38] US Department of Energy, Energy Information Administration, "Petroleum Navigator" (diesel data obtained from http://tonto.eia.doe.gov/dnav/pet/hist/kd0vabnus1a.htm; residual data obtained from http://tonto.eia.doe.gov/dnav/pet/hist/kprvatnus1a.htm).
[39] International marine fuel consumption obtained from EPA's *2007 Inventory of Greenhouse Gas Emissions and Sinks*, http://www.epa.gov/climatechange/emissions/downloads06/07Energy.pdf, table 3-51

compiled to support the development of EPA's National Emissions Inventory (NEI).[40] In keeping with the NEI, 75% of each year's distillate fuel and 25% of each year's residual fuel were assumed to be consumed within the port area (remaining consumption was assumed to occur while ships are underway). National port area fuel consumption was allocated to Maryland based on year-specific freight tonnage data for the top 150 ports in the nation as reported in "Waterborne Commerce of the United States, Part 5 – Waterways and Harbors National Summaries."[41] Offshore CO_2 and hydrocarbon (HC) emissions for Maryland's exclusive economic zone (EEZ) was taken from a study by Corbett for the Commission for Environmental Cooperation in North America (CEC).[42] Offshore CH_4 emissions were estimated by speciating the HC emissions using the California Air Resources Board's total organic gas (TOG) profile (#818).[43] Offshore N_2O emissions were estimated by applying the ratio of N_2O to CH_4 emission factors to the CH_4 emission estimate. The 2002 offshore emissions from the CEC inventory were scaled to other historic years based on the estimated port fuel consumption. Port and offshore commercial marine emissions were projected based on the 1990-2004 growth rates.

Nonroad Engines

It should be noted that fuel consumption data from EIA includes nonroad gasoline and diesel fuel consumption in the commercial and industrial sectors. Emissions from these nonroad engines are included in the inventory and forecast for the residential, commercial, and industrial (RCI) sectors. Table C6 shows how EIA divides gasoline and diesel fuel consumption between the transportation, commercial, and industrial sectors.

Table C6. EIA Classification of Gasoline and Diesel Consumption

Sector	Gasoline Consumption	Diesel Consumption
Transportation	Highway vehicles, marine	Vessel bunkering, military use, railroad, highway vehicles
Commercial	Public non-highway, miscellaneous use	Commercial use for space heating, water heating, and cooking
Industrial	Agricultural use, construction, industrial and commercial use	Industrial use, agricultural use, oil company use, off-highway vehicles

Results

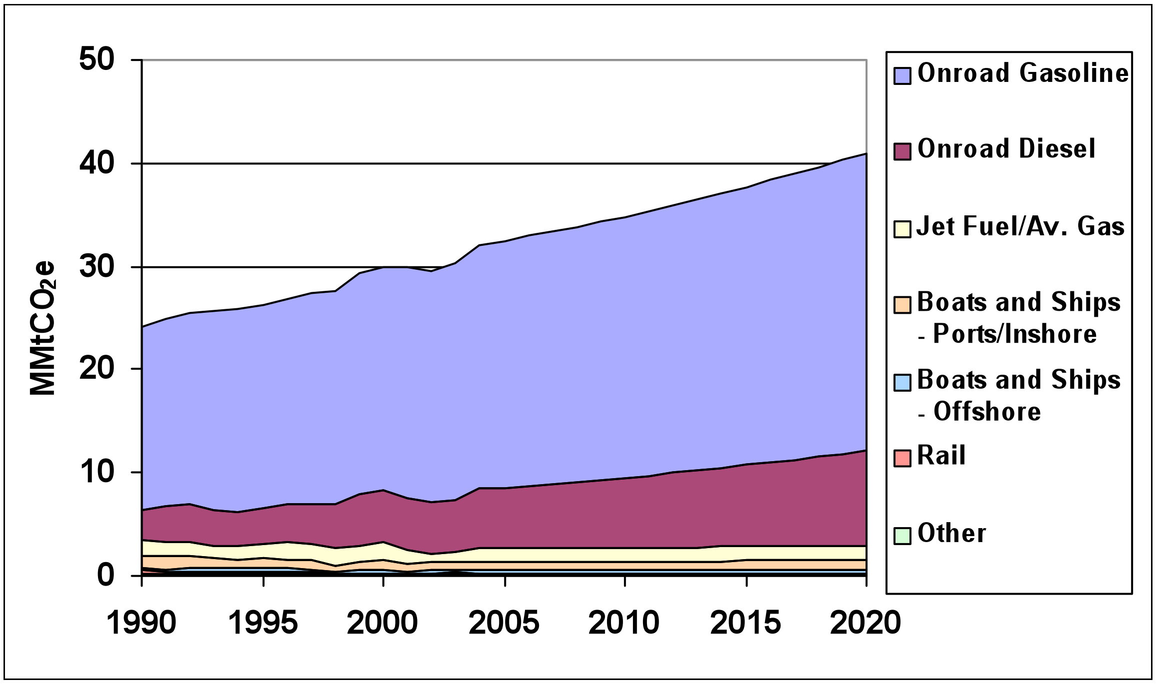
As shown in Figure C1 and Table C7, onroad gasoline consumption accounts for the largest share of transportation GHG emissions. Emissions from onroad gasoline vehicles increased by about 34% from 1990-2005, accounting for 74% of total transportation emissions in 2005. GHG emissions from onroad diesel fuel consumption increased by 103% from 1990 to 2005, and by 2005 accounted for 18% of GHG emissions from the transportation sector. Emissions from boats and ships decreased by 13% from 1990 to 2005, accounting for 4% of transportation emissions in

[40] See methods described in ftp://ftp.epa.gov/EmisInventory/2002finalnei/documentation/mobile/2002nei_mobile_nonroad_methods.pdf
[41] Note that it was necessary to estimate 1991-1995 values by interpolating between the available 1990 and 1996 estimates.
[42] Estimate, Validation, and Forecasts of Regional Commercial Marine Vessel Inventories, submitted by J. Corbett, prepared for the California Air Resources Board, California Environmental Protection Agency, and Commission for Environmental Cooperation in North America, http://coast.cms.udel.edu/NorthAmericanSTEEM/.
[43] California Air Resources Board, Speciation Profiles, http://www.arb.ca.gov/ei/speciate/speciate.htm.

2005. Emissions from all other categories combined (aviation, locomotives, natural gas and liquefied petroleum gas (LPG), and oxidation of lubricants) contributed to about 5% of total transportation emissions in 2005.

GHG emissions from onroad gasoline consumption are projected to increase by about 20%, and emissions from onroad diesel consumption are expected to increase by 56% between 2005 and 2020. GHG emissions from the aviation and marine sectors are projected to increase by 8% and 10%, respectively, from 2005 to 2020, while emissions from rail are expected to remain constant during this same period.

Figure C1. Transportation GHG Emissions by Source, 1990-2020



SSource: CCS calculations based on approach described in text.

Table C7. Gross GHG Emissions from Transportation ($MMtCO_2e$)

Source	1990	1995	2000	2005	2010	2015	2020
Onroad Gasoline	17.91	19.67	21.61	23.94	25.29	26.97	28.78
Onroad Diesel	2.91	3.42	5.09	5.89	6.83	7.91	9.18
Jet Fuel/Av. Gas	1.49	1.41	1.68	1.31	1.32	1.37	1.42
Boats and Ships - Ports/Inshore	1.16	0.90	0.90	0.87	0.81	0.87	0.93
Boats and Ships - Offshore	0.21	0.35	0.39	0.31	0.33	0.35	0.37
Rail	0.39	0.27	0.05	0.06	0.06	0.06	0.06
Other	0.14	0.14	0.16	0.14	0.16	0.18	0.19
Total	**24.20**	**26.16**	**29.90**	**32.52**	**34.81**	**37.71**	**40.93**

Key Uncertainties

Projections of VMT

A major uncertainty in this analysis is the projected increase in on-road VMT and gasoline consumption from 2005 to 2020. The VMT projections are based on developing growth rates from 1990 to 2005 historical MDE VMT data, and projected MDE VMT from 2008, 2010, and 2020, as well as national projections of the VMT mix from EIA AEO2006 data. The future year vehicle mix, which was calculated based on national growth rates for specific vehicle types, adds uncertainty because this mix may not appropriately reflect vehicle-specific growth in Maryland.

Uncertainties in Aviation Fuel Consumption

The jet fuel and aviation gasoline fuel consumption from EIA is actually fuel *purchased* in the state, and therefore, includes fuel consumed during state-to-state flights and international flights. The fuel consumption associated with international air flights should not be included in the state inventory; however, data were not available to subtract this consumption from total jet fuel estimates. Another uncertainty associated with aviation emissions is the use of general aviation forecasts to project aviation gasoline consumption. General aviation aircraft consume both jet fuel and aviation gasoline, but fuel specific data were not available.

Uncertainties in Marine Fuel Consumption

There are several assumptions that introduce uncertainty into the estimates of commercial marine fuel consumption. These assumptions include:

- 75% of marine diesel and 25% of residual fuel is consumed in port; and
- The proportion of freight tonnage at the Port of Baltimore to the total freight tonnage for the top 150 US ports reflects the proportion of national marine fuel that is consumed in Maryland.

Appendix D. Industrial Processes

Overview

Emissions in the industrial processes category span a wide range of activities, and reflect non-combustion sources of greenhouse gas (GHG) emissions from several industries. The industrial processes that exist in Maryland, and for which emissions are estimated in this inventory, include the following:

- Carbon dioxide (CO_2) from:
    - Production of cement and iron and steel;
    - Consumption of limestone, dolomite, and soda ash;
- Perfluorocarbons (PFCs) from aluminum production;
- Sulfur hexafluoride (SF_6) transformers used in electric power transmission and distribution (T&D) systems;
- Hydrofluorocarbons (HFCs) and PFCs from consumption of substitutes for ozone-depleting substances (ODS) used in cooling and refrigeration equipment; and
- HFCs, PFCs, and SF_6 from semiconductor manufacture.

Other industrial processes that are sources of GHG emissions but are not found in Maryland include the following:

- Nitrous oxide (N_2O) from nitric and adipic acid production;
- SF_6 from magnesium processing;
- CO_2 from ammonia manufacture; and
- HFCs from HCFC-22 production.

The following discusses the data sources, methods, assumptions, and results used to construct the inventory and reference case projections for this sector. The reference case projections assume business-as-usual practices.

Emissions and Reference Case Projections

Greenhouse gas emissions for 1990 through 2005 were estimated using the United States Environmental Protection Agency's (US EPA) State Greenhouse Gas Inventory Tool (SIT) software, and the methods provided in the Emission Inventory Improvement Program (EIIP) guidance document for this sector.[44] Table D1 identifies for each emissions source category the information needed for input into SIT to calculate emissions, the data sources used for the analysis described here, and the historical years for which emissions were calculated based on the availability of data.

[44] GHG emissions were calculated using SIT, with reference to EIIP, Volume VIII: Chapter. 6. "Methods for Estimating Non-Energy Greenhouse Gas Emissions from Industrial Processes", August 2004. Referred to as "EIIP" below.

Table D1. Approach to Estimating Historical Emissions

Source Category	Time Period	Required Data for SIT	Data Source
Cement Manufacturing - Clinker Production and Masonry Cement Production	Clinker: 1990 – 2005 Masonry: 1993 - 2001	Metric tons (Mt) of clinker produced and masonry cement produced each year.	Historical production for Maryland from US Geological Survey (USGS) Minerals Yearbook, Cement Statistics and Information. Data for masonry cement not available prior to 1993 and after 2001. (http://minerals.usgs.gov/minerals/pubs/commodity/cement/index.html#myb).
Limestone and Dolomite Consumption	1994 - 2005	Mt of limestone and dolomite consumed.	Historical consumption (sales) for Maryland from USGS Minerals Yearbook, Crushed Stone Statistics and Information, (http://minerals.usgs.gov/minerals/pubs/commodity/stone_crushed/). The USGS data includes limestone and dolomite reported together with no distinction between the two kinds of stone. In SIT, the state's total limestone consumption (as reported by USGS) is multiplied by the ratio of national limestone consumption for industrial uses to total national limestone consumption. Additional information on these calculations, including a definition of industrial uses, is available in Chapter 6 of the EIIP guidance document. Default limestone production data are not available in SIT for 1990 – 1993; data for 1994 were used for 1990 – 1993 as a surrogate to fill in production data missing for these years.
Soda Ash Consumption	1990 - 2005	Mt of soda ash consumed for use in consumer products such as glass, soap and detergents, paper, textiles, and food.	Historical emissions are calculated in SIT based on the state's population and national per capita soda ash consumption from the US EPA national GHG inventory. -- National historical consumption (sales) for US from USGS Minerals Yearbook, Soda Ash Statistics and Information (http://minerals.usgs.gov/minerals/pubs/commodity/soda_ash/). -- National emissions from *US Inventory of Greenhouse Gas Emissions and Sinks: 1990-2005*, US EPA, Report #430-R-07-002, April 2007 (http://epa.gov/climatechange/emissions/usinventoryreport.html). -- US (1990-2000 and 2000-2005) and state (2000-2005) population from US Census Bureau (http://www.census.gov/popest/states/NST-ann-est.html). -- State (1990-2000) population from US Census Bureau (http://www.census.gov/popest/archives/2000s/vintage_2001/CO-EST2001-12/CO-EST2001-12-24.html).
Iron and Steel Production	1997-2005	Mt of crude steel produced by production method.	The basic activity data needed are the quantities of crude steel produced (defined as first cast product suitable for sale or further processing) by production method. Default SIT values are based on the state-level production data assigned to production method based on the national distribution of production by method. National production data are from the Annual Statistics Report published by the American Iron and Steel Institute, Washington, DC (http://www.steel.org/AM/Template.cfm?Section=Bookstore&CONTENTID=12259&TEMPLATE=/CM/HTMLDisplay.cfm). Default production data are not available in SIT for 1990-1996; data for these years are based on 1997 production.
Aluminum Production	1990 - 2005	Mt of aluminum produced each year.	Historical production for Maryland from USGS Minerals Yearbook, Aluminum Statistics and Information (http://minerals.usgs.gov/minerals/pubs/commodity/aluminum/).
ODS Substitutes	1990 - 2005	Based on state's population and estimates of emissions per capita from the US EPA national GHG inventory.	References for US EPA national emissions and US Census Bureau national and state population figures are cited under the data sources for soda ash above.

Source Category	Time Period	Required Data for SIT	Data Source
Electric Power T&D Systems	1990 - 2005	Emissions from 1990 to 2005 based on the national emissions per kilowatt-hour (kWh) and state's electricity use provided in SIT.	National emissions are apportioned to the state based on the ratio of state-to-national electricity sales data provided in the Energy Information Administration's (EIA) Electric Power Annual (http://www.eia.doe.gov/cneaf/electricity/epa/epa_sum.html). Reference for US EPA national emissions is cited under the data sources for soda ash above.
Semiconductor Manufacture	1990 - 2005	State and national value of semiconductor shipments for NAICS code 334413 (Semiconductor and Related Device Manufacturing).	Method uses ratio of state-to-national value of semiconductor shipments to estimate state's proportion of national emissions for 1990–2005. Value of shipments from U.S Census Bureau's 1997 and 2002 Economic Census (http://www.census.gov/econ/ census02/). Reference for US EPA national emissions is cited under the data sources for soda ash above.

Table D2 lists the data and methods that were used to estimate future activity levels related to industrial process emissions and the annual compound growth rates computed from the data/methods for the reference case projections. Because available forecast information is generally for economic sectors that are too broad to reflect trends in the specific emissions producing processes, the majority of projections are based on historical activity trends. In particular, state historical trends were analyzed for three periods: 1990-2005, 1995-2005, and 2000-2005 (or the closest available approximation of these periods).

Results

Figures D1 and D2 show historic and projected emissions for the industrial processes sector from 1990 to 2020. Table D3 shows the historic and projected emission values upon which Figures D1 and D2 are based. Total gross GHG emissions were about 2.6 MMtCO_2e in 1990, 4.9 MMtCO_2e in 2005, and are projected to increase to about 8.8 MMtCO_2e in 2020. Emissions from the overall industrial processes category are expected to grow by about 4.0% annually from 2005 through 2020, as shown in Figures D1 and D2, with emissions growth primarily associated with increasing use of HFCs and PFCs in refrigeration and air conditioning equipment.

Table D2. Approach to Estimating Projections for 2005 through 2020

			Annual Growth Rates (%)		
Source Category	Projection Assumptions	Data Source	2005 to 2010	2010 to 2015	2015 to 2020
Cement Production	Based on 15-year historical annual increase in state production from each of three periods analyzed.	Annual change in Maryland clinker production: 1990-2005 = 2.6%; 1995-2005 = 9.1%; and 2000-2005 = 8.3%	2.6	2.6	2.6
Limestone and Dolomite Consumption	Based on 15-year historical annual increase in state production from each of three periods analyzed.	Annual change in Maryland limestone and dolomite consumption: 1990-2005 = 1.0%; 1995-2005 = -1.0% 2000-2005 = 3.8%	1.0	1.0	1.0
Soda Ash Consumption	Based on 15-year historical annual change in state production from each of three periods analyzed.	Annual change in Maryland soda ash consumption: 1990-2005 = -0.5% 1995-2005 = -0.6% 2000-2005 = -0.6%	-0.5	-0.5	-0.5

Iron and Steel Production	Based on historical annual change in state production from each of two periods analyzed.	Annual change in Maryland iron and steel production: 1997-2005 = -1.4% 2000-2005 = -1.4%	-1.4	-1.4	-1.4
Aluminum Production	Based on 15-year historical annual increase in state production from each of three periods analyzed.	Annual change in Maryland aluminum production: 1990-2005 = 1.4% 1995-2005 = 3.3% 2000-2005 = 5.5%	1.4	1.4	1.4
ODS Substitutes	National growth in emissions associated with the use of ODS substitutes.	Annual growth rates calculated based on sum of US national emissions projections from 2005 through 2020 for six categories of ODS substitutes presented in Appendix D, Tables D-1 through D-6 in the US EPA report, *Global Anthropogenic Emissions of Non-CO_2 Greenhouse Gases 1990-2020*, EPA Report #430-R-06-003 (http://www.epa.gov/nonco2/econ-inv/international.html).	8.7	6.4	5.0
Electric Power T&D Systems	National growth rate (based on technology adoption forecast scenario reflecting industry participation in EPA voluntary stewardship program to control emissions).	Annual growth rates calculated based on US national emissions projections from 2005 through 2020 presented in Appendix D, Table D-10 in the US EPA report, *Global Anthropogenic Emissions of Non-CO_2 Greenhouse Gases 1990-2020* , EPA Report 430-R-06-003 (http://www.epa.gov/nonco2/econ-inv/international.html).	-1.6	-0.8	-0.7
Semiconductor Manufacturing	Ditto	Ditto	0.7	-4.2	-1.4

Figure D1. GHG Emissions from Industrial Processes, 1990-2020

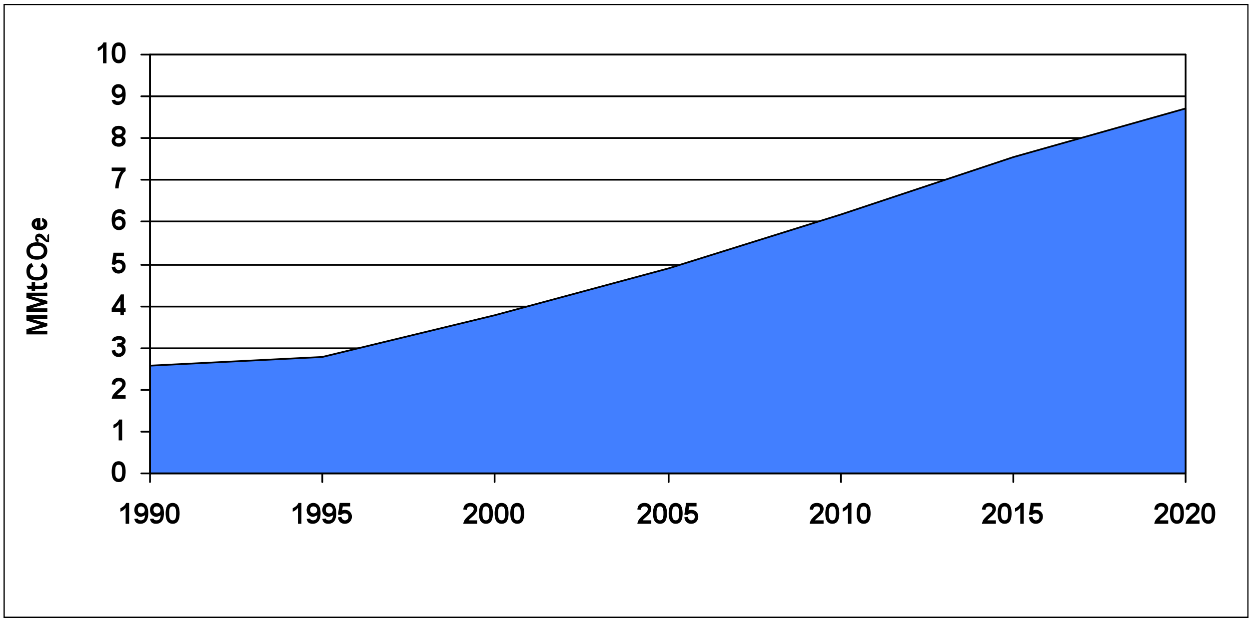


Figure D2. GHG Emissions from Industrial Processes, 1990-2020, by Source

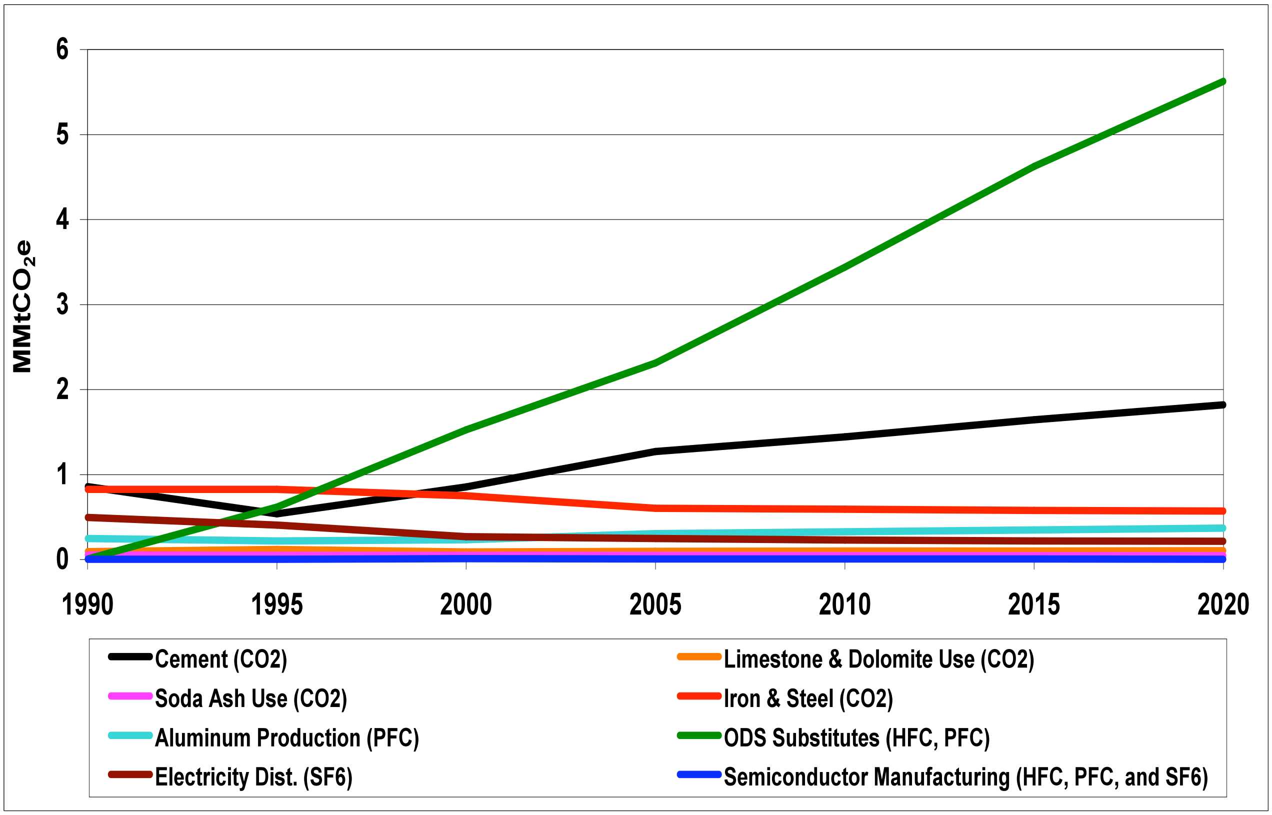


Table D3. Historic and Projected Emissions for the Industrial Processes Sector ($MMtCO_2e$)

Industry / Pollutant	1990	1995	2000	2005	2010	2015	2020
Cement (CO_2)	0.86	0.54	0.86	1.27	1.45	1.64	1.82
Limestone & Dolomite Use (CO_2)	0.09	0.12	0.09	0.11	0.11	0.12	0.12
Soda Ash Use (CO_2)	0.052	0.052	0.050	0.049	0.047	0.046	0.045
Iron & Steel (CO_2)	0.83	0.83	0.75	0.60	0.56	0.53	0.50
Aluminum Production (PFCs)	0.25	0.22	0.23	0.30	0.33	0.35	0.37
ODS Substitutes (HFC, PFC)	0.01	0.62	1.53	2.31	3.44	4.62	5.63
Electricity Dist. (SF_6)	0.50	0.41	0.27	0.25	0.23	0.22	0.21
Semiconductor Manufacturing (HFC, PFC, and SF_6)	0.003	0.004	0.009	0.007	0.007	0.005	0.005
Total	**2.58**	**2.78**	**3.78**	**4.90**	**6.17**	**7.53**	**8.70**

Cement Manufacture

Clinker is an intermediate product from which finished Portland and masonry cement are made. Clinker production releases CO_2 when calcium carbonate ($CaCO_3$) is heated in a cement kiln to form lime (calcium oxide) and CO_2 (see Chapter 6 of EIIP guidance document). Emissions are calculated by multiplying annual clinker production by emission factors to estimate emissions associated with the clinker production process (0.507 metric ton (Mt) of CO_2 emitted per Mt of clinker produced) and cement kiln dust (0.020 $MtCO_2$ emitted per Mt of clinker CO_2 emitted).

Masonry cement requires additional lime, over and above the lime used in the clinker. During the production of masonry cement, non-plasticizer additives such as lime, slag, and shale are added to the cement, increasing its weight by 5%. Lime accounts for approximately 60% of the added substances. About 0.0224 $MtCO_2$ is emitted for every Mt of masonry cement produced, relative to the CO_2 emitted during the production of a Mt of clinker (see Chapter 6 of EIIP guidance document).

As shown in Figure D2 (see black line) and Table D3, emissions from this source are estimated to be about 0.86 $MMtCO_2e$ in 1990 and are projected to increase to about 1.82 $MMtCO_2e$ by 2020. Historical clinker production data obtained from the US Geological Survey (USGS) (see Table D1) and the default emission factors in SIT were used to calculate CO_2 emissions for 1990-2005. The annual average rate of increase in Maryland clinker/masonry cement production over the 1990-2005 period (2.6% per year) was used to project emissions from 2006 to 2020. Masonry cement production was not included in the growth rate analysis because of a lack of data prior to 1993 and after 2001 and because masonry cement production was highly variable over this time period. Masonry cement production ranged from a low of less than 1% to a high of 7% of clinker production in 1991 and 1996 through 2001, but was as high as 17% and 18% of total clinker production in 1995 and 1994, respectively.

Limestone and Dolomite Consumption

Limestone and dolomite are basic raw materials used by a wide variety of industries, including the construction, agriculture, chemical, glass manufacturing, and environmental pollution control industries, as well as in metallurgical industries such as magnesium production. Emissions associated with the use of limestone and dolomite to manufacture steel and glass and for use in flue-gas desulfurization scrubbers to control sulfur dioxide emissions from the combustion of coal in boilers are included in the industrial processes sector.[45]

As shown in Figure D2 and Table D3, emissions from this source are estimated to be about 0.09 $MMtCO_2e$ in 1990 and are projected to increase to about 0.12 $MMtCO_2e$ by 2020 (see orange line at the bottom of Figure D2). Historical limestone and dolomite consumption (sales) data for Maryland obtained from the USGS (see Table D1) and the default emission factors in SIT were used to calculate CO_2 emissions for 1990-2005. Note that the USGS limestone and dolomite consumption are combined. For this analysis, it was assumed that the majority of the consumption was limestone rather than dolomite; therefore, the SIT emission factor for limestone (0.044 $MtCO_2$ per Mt of limestone) was used to calculate emissions rather than the emission factor for dolomite (0.0484 Mt CO_2 per Mt of dolomite). The annual average rate of increase in Maryland limestone and dolomite consumption over the 1990-2005 period (1.0% per year) was used to project emissions from 2006 to 2020.

[45] In accordance with EIIP Chapter 6 methods, emissions associated with the following uses of limestone and dolomite are not included in this category: (1) crushed limestone consumed for road construction or similar uses (because these uses do not result in CO_2 emissions), (2) limestone used for agricultural purposes (which is counted under the methods for the agricultural sector), and (3) limestone used in cement production (which is counted in the methods for cement production).

Soda Ash Use

Commercial soda ash (sodium carbonate) is used in many consumer products such as glass, soap and detergents, paper, textiles, and food. Carbon dioxide is also released when soda ash is consumed (see Chapter 6 of EIIP guidance document). As shown in Table D3, emissions from this source are estimated to be about 0.052 $MMtCO_2e$ in 1990 and are projected to decline to about 0.045 $MMtCO_2e$ in 2020 (due to scale effects the emissions cannot be seen Figure D2). Historical emissions are calculated in SIT based on the state's population and national per capita soda ash consumption from the US EPA national GHG inventory. The annual average rate of change in Maryland soda ash use over the 1990-2005 15-year period (-0.5% per year) was used to project emissions from 2006 to 2020.

Iron and Steel Production

The production of iron and steel generate process-related CO_2 emissions. Iron is produced by reducing iron ore with metallurgical coke in a blast furnace to produce pig iron; this process emits CO_2 emissions. Pig iron is used as a raw material in the production of steel. The production of metallurgical coke from coking coal produces CO_2 emissions as well.

Historical CO_2 emissions were estimated using the SIT default activity data (see Table D1) for 1997-2005 and emission factors for the following production methods: basic oxygen furnace at integrated mill with coke ovens, basic oxygen furnace at integrated mill without coke ovens, electric arc furnace, and open hearth furnace. The basic activity data needed are the quantities of crude steel produced (defined as first cast product suitable for sale or further processing) by production method. Default values are based on the state-level production data assigned to each production method based on the national distribution of production by method. The national production data were obtained from the Annual Statistics Report published by the American Iron and Steel Institute, Washington, DC (see Table D1). Production data are not available in SIT for 1990-1996; data for these years are based on 1997 production. As shown in Figure D2 (see red line) and Table D3, emissions in 1990 were 0.83 $MMtCO_2e$ and are projected to decline to about 0.50 $MMtCO_2e$ in 2020. The annual average rate of change in Maryland's iron and steel production over the 1997-2005 period (-1.4% per year) was used to project emissions from 2006 to 2020.

Aluminum Production

The aluminum production industry is thought to be the largest source of two perfluorocarbons (PFCs) – tetrafluoromethane (CF_4) and hexafluoroethane (C_2F_6). Emissions of these two potent GHGs occur during the reduction of alumina in the primary smelting process (see Chapter 6 of the EIIP guidance document). As shown in Figure D2 (see turquoise line) and Table D3, emissions in 1990 were 0.25 $MMtCO_2e$ and are projected to increase to about 0.37 $MMtCO_2e$ in 2020. Historical aluminum production data obtained from the USGS (see Table D1) and the default emission factors in SIT were used to calculate CO_2 emissions for 1990-2005. The annual average rate of increase in Maryland aluminum production over the 1990-2005 period (1.4% per year) was used to project emissions from 2006 to 2020.

Substitutes for Ozone-Depleting Substances (ODS)

HFCs and PFCs are used as substitutes for ODS, most notably CFCs (CFCs are also potent warming gases, with global warming potentials on the order of thousands of times that of CO_2 per unit of emissions) in compliance with the *Montreal Protocol* and the *Clean Air Act Amendments of 1990*.[46] Even low amounts of HFC and PFC emissions, for example, from leaks and other releases associated with normal use of the products, can lead to high GHG emissions on a CO_2e basis. Emissions have increased from 0.01 $MMtCO_2e$ in 1990 to about 1.53 $MMtCO_2e$ in 2000, and are expected to increase at an average rate of 6.7% per year from 2000 to 2020 due to increased substitutions of these gases for ODS (see dark green line in Figure D2). The projected rate of increase for these emissions is based on projections for national emissions from the US EPA report referenced in Table D2.

Electric Power Transmission and Distribution

Emissions of SF_6 from electrical equipment have experienced declines since the mid nineties (see brown line in Figure D2), mostly due to voluntary action by industry. Sulfur hexafluoride is used as an electrical insulator and interrupter in the electric power T&D system. The largest use for SF_6 is as an electrical insulator in electricity T&D equipment, such as gas-insulated high-voltage circuit breakers, substations, transformers, and transmission lines, because of its high dielectric strength and arc-quenching abilities. Not all of the electric utilities in the US use SF_6; use of the gas is more common in urban areas where the space occupied by electric power T&D facilities is more valuable.[47]

As shown in Figure D2 and Table D3, SF_6 emissions from electric power T&D are about 0.50 $MMtCO_2e$ in 1990 and 0.21 $MMtCO_2e$ in 2020. Emissions in Maryland from 1990 to 2005 were estimated based on the estimates of emissions per kilowatt-hour (kWh) of electricity consumed from the US EPA GHG inventory, and the ratio of Maryland's to the US electricity consumption (sales) estimates available from the Energy Information Administration's (EIA) Electric Power Annual and provided in SIT (see Table D1). The national trend in US emissions estimated for 2005-2020 for the technology-adoption scenario shows expected decreases in these emissions at the national level (see Table D2), and the same rate of decline is assumed for emissions in Maryland. The decline in SF_6 emissions in the future reflects expectations of future actions by the electric power industry to reduce these emissions.

Semiconductor Manufacture

The semiconductor industry uses fluorinated gases (PFCs [CF_4, C_2F_6, and C_3F_8]; HFC-23; and SF_6) in plasma etching and chemical vapor deposition processes. Emissions of SF_6 and HFCs from the manufacture of semiconductors have experienced declines since 2000. Emissions for Maryland from 1990 to 2005 were estimated based on the default estimates provided in SIT, which uses the ratio of the state-to-national value of semiconductor shipments to estimate the

[46] As noted in EIIP Chapter 6, ODS substitutes are primarily associated with refrigeration and air conditioning, but also many other uses including as fire control agents, cleaning solvents, aerosols, foam blowing agents, and in sterilization applications. The applications, stocks, and emissions of ODS substitutes depend on technology characteristics in a range of equipment types. For the US national inventory, a detailed stock vintaging model was used to track ODS substitutes uses and emissions, but this modeling approach has not been completed at the state level.
[47] US EPA, Draft User's Guide for Estimating Carbon Dioxide, Nitrous Oxide, HFC, PFC, and SF_6 Emissions from Industrial Processes Using the State Inventory Tool, prepared by ICF International, March 2007.

state's proportion of national emissions from the US EPA GHG inventory (see Table D1). The national trend in US emissions estimated for 2005-2020 for the technology-adoption scenario shows expected decreases in these emissions at the national level (see Table D2), and the same rate of decline is assumed for emissions in Maryland. The decline in emissions in the future reflects expectations of future actions by the semiconductor industry to reduce these emissions. Relative to total industrial non-combustion process emissions, estimated emissions associated with semiconductor manufacturing are low (about 0.003 $MMtCO_2e$ in 1990, 0.007 $MMtCO_2e$ in 2005, and 0.005 $MMtCO_2e$ in 2020), and therefore, cannot be seen in Figure D2 due to scaling effects.

Key Uncertainties

Key sources of uncertainty underlying the estimates above are as follows:

- Since emissions from industrial processes are determined by the level of production and the production processes of a few key industries—and in some cases, a few key plants—there is relatively high uncertainty regarding future emissions from the industrial processes category as a whole. Future emissions depend on the competitiveness of Maryland manufacturers in these industries, and the specific nature of the production processes used in Maryland.
- The projected largest source of future industrial emissions, HFCs and PFCs used in cooling applications, is subject to several uncertainties as well. Emissions through 2020 and beyond will be driven by future choices regarding mobile and stationary air conditioning technologies and the use of refrigerants in commercial applications, for which several options currently exist.
- Due to the lack of reasonably specific projection surrogates, historical trend data were used to project emission activity level changes for multiple industrial processes. There is significant uncertainty associated with any projection, including a projection that assumes that past historical trends will continue in future periods.
- For the industries for which EPA default activity data and methods were used to estimate historical emissions, future work should include efforts to obtain state-specific data to replace the default assumptions. In particular, for the iron and steel, aluminum, electric power T&D, and semiconductor industries, future efforts should include a survey of companies within these industries to determine the extent to which they are implementing techniques to minimize emissions to improve the emission projections for these industries.
- Because of a lack of activity data for the early 1990's, iron and steel production for 1997 activity data were used as a surrogate to estimate emissions for 1990 through 1996. For limestone and dolomite consumption, 1994 activity data were used as a surrogate to estimate emissions for 1990 through 1993. Future work should include efforts to obtain actual activity data for the years for which the data were not available for this analysis to minimize uncertainties associated with the use of the surrogate data.

Appendix E. Fossil Fuel Production Industry

Overview

The inventory for this subsector of the Energy Supply sector includes methane (CH_4), nitrous oxide (N_2O), and carbon dioxide (CO_2) emissions associated with the production, processing, transmission, and distribution of fossil fuels in Maryland.[48] There is no oil production or oil or natural gas processing in Maryland. In 2005, the fossil fuel production industry accounted for an estimated 1.08 million metric tons (MMt) of CO_2 equivalent (CO_2e) of total gross greenhouse gas (GHG) emissions in Maryland, and is estimated to increase to about 1.11 $MMtCO_2e$ by 2020.

Emissions and Reference Case Projections

Emissions for 1990 through 2005 were estimated using the United States Environmental Protection Agency's (US EPA) State Greenhouse Gas Inventory Tool (SIT) software and the methods provided in the Emission Inventory Improvement Program (EIIP) guidance document for natural gas and oil systems.[49] Table E1 provides an overview of the required data, data sources, and the approach to projecting future emissions. The activity data were entered into the SIT to calculate emissions for 1990 through 2005. Emissions were calculated by multiplying emissions-related activity levels (e.g., miles of pipeline) by aggregate emission factors.

Oil and Gas Production

Natural gas production emissions are estimated for the number of operating natural gas producing wells in the state (no oil production emissions are estimated for Maryland because the state does not produce crude oil or have any petroleum refineries).[50] Natural gas production emissions were held constant in forecast years because the number of operating natural gas producing wells was fairly constant throughout the historical period.

Based on the information provided in the Emission Inventory Improvement Program (EIIP) guidance[51] for estimating emissions for this sector, transmission pipelines are large diameter, high-pressure lines that transport gas from production fields, processing plants, storage facilities, and other sources of supply over long distances to local distribution companies or to large volume customers. Sources of CH_4 emissions from transmission pipelines include leaks, compressor fugitives, vents, and pneumatic devices. Distribution pipelines are extensive networks of generally small diameter, low-pressure pipelines that distribute gas within cities or towns. Sources of CH_4 emissions from distribution pipelines are leaks, meters, regulators, and mishaps. Carbon dioxide, CH_4, and N_2O emissions occur as the result of the combustion of natural gas by internal combustion engines used to operate compressor stations.

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[48] Note that emissions from natural gas consumed as lease fuel (used in well, field, and lease operations) and plant fuel (used in natural gas processing plants) are included in Appendix B in the industrial fuel combustion category.
[49] Methane emissions were calculated using SIT, with reference to Emission Inventory Improvement Program, Volume VIII: Chapter. 5. "Methods for Estimating Methane Emissions from Natural Gas and Oil Systems," March 2005.
[50] US Department of Energy, Energy Information Administration, "State Energy Profile – Maryland," accessed from http://tonto.eia.doe.gov/state/state_energy_profiles.cfm?sid=MD, December 2007.
[51] Emission Inventory Improvement Program, Volume VIII: Chapter 5. "Methods for Estimating Methane Emissions from Natural Gas and Oil Systems," August 2004.

Table E1. Approach to Estimating Historical and Future GHG Emissions from the Fossil Fuel Production Industry

	Approach to Estimating Historical Emissions		Approach to Estimating Projections
Activity	*Required Data for SIT*	*Data Source*	*Projection Assumptions*
Natural Gas Drilling and Field Production	Number of wells	EIA[52]	No change because no change in activity over 3 periods analyzed (1990-2005; 1995-2005; and 2000-2005)
	Miles of gathering pipeline	Office of Pipeline Safety (OPS)[53]	
Natural Gas Transmission	Miles of transmission pipeline	OPS[49]	Based on AEO2006[54] projected average annual growth in natural gas consumption in the South Atlantic Region over three periods: 1.96 % from 2005 to 2010, 1.75% from 2010 to 2015, and 1.46% from 2015 to 2020.
	Number of gas transmission compressor stations	EIIP[55]	
	Number of gas storage compressor stations	EIIP[56]	
	Number of LNG storage compressor stations	Not estimated because data unavailable	
Natural Gas Distribution	Miles of distribution pipeline	OPS[49]	Same as Natural Gas Transmission above.
	Total number of services		
	Number of unprotected steel services		
	Number of protected steel services		
Natural Gas Pipeline Fuel Use (CO_2, CH_4, N_2O)	Volume of natural gas consumed by pipelines	EIA[57]	Application of smallest annualized decline in pipeline fuel consumption (-0.54%) from each of 3 periods analyzed (1990-2005).
Coal Mining	Methane emissions in million cubic feet	US. Environmental Protection Agency (EPA)[58]	Based on AEO2006[50] projected average annual growth/decrease in coal production in the North Appalachian region over three periods: 4.63 % from 2005 to 2010, 0.52% from 2010 to 2015, and –0.22% from 2015 to 2020.

[52] US Department of Energy, Energy Information Administration, "Natural Gas Navigator - Maryland Natural Gas Number of Gas and Gas Condensate Wells," accessed from http://tonto.eia.doe.gov/dnav/ng/hist/na1170_smd_8a.htm, December 2007.
[53] US Department of Transportation, Office of Pipeline Safety, "Distribution and Transmission Annuals Data: 1990 to 2005," accessed from http://ops.dot.gov/stats/DT98.htm, December 2007.
[54] US Department of Energy, Energy Information Administration, "Annual Energy Outlook 2006 with Projections to 2030," accessed from, December 2007.
[55] Number of gas transmission compressor stations = miles of transmission pipeline x 0.006 – EIIP, Volume VIII: Chapter 5, March 2005.
[56] Number of gas storage compressor stations = miles of transmission pipeline x 0.0015 EIIP. Volume VIII: Chapter 5, March 2005.
[57] US DOE, Energy Information Administration, *State Energy Consumption, Price, and Expenditure Estimates (SEDS)*, (http://www.eia.doe.gov/emeu/states/_seds.html).
[58] US Environmental Protection Agency, "Inventory of US Greenhouse Gas Emissions and Sinks: 1990-2005, USEPA #430-R-07-002, http://www.epa.gov/climatechange/emissions/usinventoryreport.html, April 2007.

The annual activity data for miles of T&D pipeline and number of service connections to distribution pipelines were obtained from databases provided by the Office of Pipeline Safety (OPS).[49] For the distribution system, annual CH_4 emissions were estimated using OPS' pipeline mileage and the SIT emission factors for (1) distribution pipeline constructed of cast iron, unprotected steel, protected steel, and plastic, and (2) the number of protected and unprotected service connections. For the transmission system, the SIT methods use total miles of pipeline as the basis for calculating CH_4 emissions; separate emission factors are not provided for pipeline constructed of different materials.

Three revisions to the OPS' data were implemented for Maryland. Year 1991, 1992, and 2002 distribution pipeline mileage and service count values were interpolated from the OPS' values for the surrounding years (i.e., values for 1990 and 1993 were used to interpolate values for 1991) because Washington Gas Light Company (Washington), which accounts for a significant portion of total distribution mileage/service counts, was missing from the data set in 1991, 1992, and 2002. Similarly, transmission pipeline mileage was interpolated for 1991, 1992 and 1993 based on the available OPS' 1990 and 1994 values because Washington was also missing from the OPS' transmission data set in these years.[59]

The SIT methods also include emission factors for estimating CH_4 emissions associated with leaks from gas transmission compressor stations, gas storage compressor stations, and liquefied natural gas (LNG) storage compressor stations. Information on the type and number of compressor stations was not readily available for Maryland. Therefore, the per mile of transmission pipeline-based SIT default factors were used to estimate the number of gas transmission compressor stations and gas storage compressor stations.[51,52] For gas transmission compressor stations, the default SIT methods estimates only one station for each year from 1990 through 2000, three stations for 2001, and five stations for each year from 2002 through 2005. For gas storage compressor stations, the SIT methods estimated no stations for 1990 through 2000 and only one station for each year afterwards. Note that the SIT does not provide default data or methods for estimating the number of LNG storage compressor stations in a state; therefore, emissions were not estimated for LNG storage compressor stations. Emissions of CO_2, CH_4, and N_2O associated with pipeline natural gas combustion are estimated using SIT emission factors[60] and Maryland 1990-2005 natural gas data from EIA for the "consumed as pipeline fuel" category.[53]

The following compound annual average growth rates were applied to forecast emissions associated with natural gas T&D: 2005-2010 = 1.96%; 2011-2015 = 1.75%; and 2016-2020 = 1.46%. These growth rate assumptions are based on US Department of Energy (DOE), Energy Information Administration (EIA)'s South Atlantic region natural gas consumption forecasts.[50] A -0.54% compound annual average growth rates was applied to forecast post-2005 emissions associated with natural gas pipeline fuel use.

[59] An additional anomaly that was identified in the OPS data was that the Baltimore Gas & Electric Company record for 1991 appears to miscategorize more than 100,000 service connections as protected steel instead of plastic. This concern is addressed via the interpolation of the 1991 service connection values noted earlier.
[60] GHG emissions were calculated using SIT, with reference to *EIIP, Volume VIII*: Chapter 1 "Methods for Estimating Carbon Dioxide Emissions from Combustion of Fossil Fuels," August 2004, and Chapter 2 "Methods for Estimating Methane and Nitrous Oxide Emissions from Stationary Combustion," August 2004.

Coal Production Emissions

Methane occurs naturally in coal seams, and is typically vented during mining operations for safety reasons. Coal mine CH_4 emissions are usually considerably higher, per unit of coal produced, from underground mining than from surface mining.

Maryland's 16 operational coal mines, only three of which are underground, produced 5.2 million short tons of coal in 2005.[61] As reported in this inventory, CH_4 emissions from coal mines are as reported by the EPA, and include emissions from surface and underground coal mines, as well as post-mining activities.[54]

With increasing coal production in the state, coal mine CH_4 emissions grew at an average annual rate of 4.93% between 2000 and 2005. Projections of future coal mine CH_4 emissions are based on EIA's forecast of coal production in the North Appalachian region: +4.63 % from 2005 to 2010, +0.52% from 2010 to 2015, and –0.22% from 2015 to 2020.[50]

Results
Table E2 displays the estimated emissions from the fossil fuel production industry in Maryland for select years over the period 1990 to 2020. Emissions from this sector grew by 12% from 1990 to 2005 and are projected to increase by a further 3% between 2005 and 2020. The natural gas industry is the major contributor to emissions throughout the analysis period.

Table E2. Historical and Projected Emissions for the Fossil Fuel Production Industry

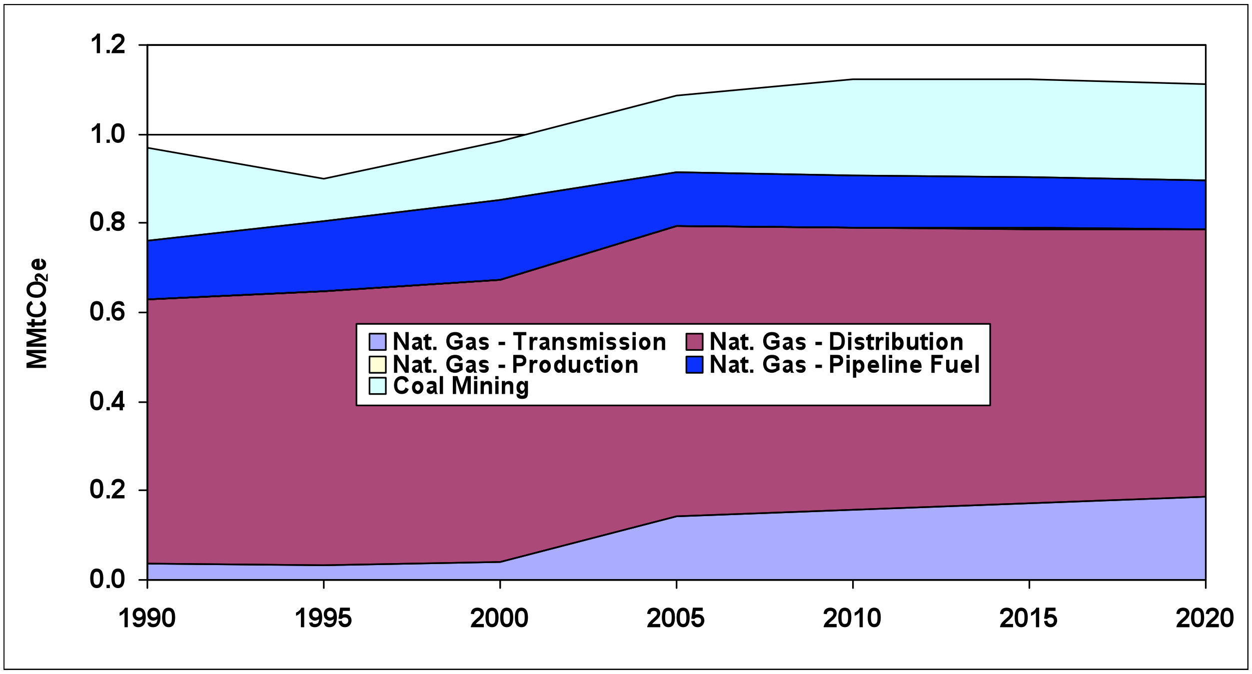
(Million Metric Tons CO_2e)	1990	1995	2000	2005	2010	2015	2020
Fossil Fuel Production Industry	0.97	0.90	0.99	1.08	1.12	1.12	1.11
Natural Gas Industry	0.76	0.80	0.85	0.91	0.91	0.90	0.90
Production	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Transmission	0.04	0.03	0.04	0.14	0.16	0.17	0.19
Distribution	0.59	0.62	0.63	0.65	0.71	0.78	0.84
Pipeline Fuel	0.13	0.15	0.18	0.12	0.12	0.11	0.11
Coal Mining	0.21	0.10	0.13	0.17	0.21	0.22	0.22

Source: Calculations based on approach described in text.

Figure E1 displays the estimated GHG emissions associated with Maryland's fossil fuel production industry from 1990 to 2005, with projections to 2020. Emissions associated with this sector are estimated to be about 0.97 $MMtCO_2e$ in 1990, 1.08 $MMtCO_2e$ in 2005, and 1.11 $MMtCO_2e$ in 2020.

[61] EIA coal data accessed at http://www.eia.doe.gov/cneaf/coal/page/acr/table1.html, December 2007.

Figure E1. Fossil Fuel Production Industry Emission Trends (MMtCO$_2$e)



Source: Calculations based on approach described in text.

Key Uncertainties

The main uncertainties are associated with the reference case projection assumptions. For most source categories, the forecasts assumed that emissions would increase at the projected rate of total natural gas consumption for the AEO2006 South Atlantic modeling region, which consists of eight other states. Market factors (e.g., price of natural gas relative to other available energy sources) could have a significant impact on the growth for this sector. In addition, neither potential future application of improvements to pipeline technologies that can yield emission reductions nor the potential effect of demand-side management programs in reducing gas consumption have been accounted for in the emissions projections shown here.

Future improvements to the estimates for the inventory could include the collection of activity data from gas companies/state of Maryland to (1) verify the OPS data used for the miles of T&D pipeline and distribution service connections, (2) replace the SIT defaults for estimating the number of gas transmission compressor stations and gas storage compressor stations, and (3) estimate emissions associated with LNG storage compressor stations if it is determined that these stations exist in Maryland.

For the natural gas T&D sector, there are limitations to the OPS data and emissions for Maryland. The OPS has revised its forms such that operators must now report their activity data by state starting in 2001 for transmission pipelines and 2004 for distribution pipelines and service connections. Prior to 2001 for transmission pipelines and 2004 for distribution pipelines and service connections, operators in Maryland have been allowed to report on the OPS form their pipeline system information as a total across multiple states. Thus, for these years the activity data for operators that included multi-state data in their reporting forms cannot be disaggregated to the state level without the assistance of the operators. Because of this constraint, pipeline activity data were included only when Maryland was reported as the only state of record. To the extent that operators of Maryland pipelines reported their mileage/service connections from 1990 to 2000 for transmission pipelines and 1990 to 2003 for distribution pipelines as multi-state totals, this inventory is under-reporting activity/emissions in these years. In addition, the OPS has noted that the reporting of activity data by individual operators may not be consistent between years over which an ownership transfer occurs, thus causing one operator's mileage to decrease while another operator's mileage increases. This issue can be associated with transfers in ownership, which may cause one operator's mileage to decrease while another operator's mileage increases. Future work should ask that operators in Maryland review and correct the historical data to ensure that T&D pipeline mileage and service connections exclude data for other states.

Appendix F. Agriculture

Overview

The emissions discussed in this appendix refer to non-energy methane (CH_4) and nitrous oxide (N_2O) emissions from enteric fermentation, manure management, and agricultural soils. Emissions and sinks of carbon in agricultural soils are also covered. Energy emissions (combustion of fossil fuels in agricultural equipment) are included in the residential, commercial, and industrial (RCI) sector estimates (see Appendix B).

There are two livestock sources of greenhouse gas (GHG) emissions: enteric fermentation and manure management. Methane emissions from enteric fermentation are the result of normal digestive processes in ruminant and non-ruminant livestock. Microbes in the animal digestive system breakdown food and emit CH_4 as a by-product. More CH_4 is produced in ruminant livestock because of digestive activity in the large fore-stomach. Methane and N_2O emissions from the storage and treatment of livestock manure (e.g., in compost piles or anaerobic treatment lagoons) occur as a result of manure decomposition. The environmental conditions of decomposition drive the relative magnitude of emissions. In general, the more anaerobic the conditions are, the more CH_4 is produced because decomposition is aided by CH_4 producing bacteria that thrive in oxygen-limited conditions. Under aerobic conditions, N_2O emissions are dominant. Emissions estimates from manure management are based on manure that is stored and treated on livestock operations. Emissions from manure that is applied to agricultural soils as an amendment or deposited directly to pasture and grazing land by grazing animals are accounted for in the agricultural soils emissions.

The management of agricultural soils can result in N_2O emissions and net fluxes of carbon dioxide (CO_2) causing emissions or sinks. In general, soil amendments that add nitrogen to soils can also result in N_2O emissions. Nitrogen additions drive underlying soil nitrification and de-nitrification cycles, which produce N_2O as a by-product. The emissions estimation methodologies used in this inventory account for several sources of N_2O emissions from agricultural soils, including decomposition of crop residues, synthetic and organic fertilizer application, manure application, sewage sludge, nitrogen fixation, and histosols (high organic soils, such as wetlands or peatlands) cultivation. Both direct and indirect emissions of N_2O occur from the application of manure, fertilizer, and sewage sludge to agricultural soils. Direct emissions occur at the site of application and indirect emissions occur when nitrogen leaches to groundwater or in surface runoff and is transported off-site before entering the nitrification/denitrification cycle. Methane and N_2O emissions also result when crop residues are burned. Methane emissions occur during rice cultivation; however, rice is not grown in Maryland.

The net flux of CO_2 in agricultural soils depends on the balance of carbon losses from management practices and gains from organic matter inputs to the soil. Carbon dioxide is absorbed by plants through photosynthesis and ultimately becomes the carbon source for organic matter inputs to agricultural soils. When inputs are greater than losses, the soil accumulates carbon and there is a net sink of CO_2 into agricultural soils. In addition, soil disturbance from the cultivation of histosols releases large stores of carbon from the soil to the atmosphere. Finally, the practice of adding limestone and dolomite to agricultural soils results in CO_2 emissions.

Emissions and Reference Case Projections

Methane and Nitrous Oxide

GHG emissions for 1990 through 2005 were estimated using the United States Environmental Protection Agency's (US EPA) State Greenhouse Gas Inventory Tool (SIT) software and the methods provided in the Emission Inventory Improvement Program (EIIP) guidance document for the sector.[62] In general, the SIT methodology applies emission factors developed for the US to activity data for the agriculture sector. Activity data include livestock population statistics, crop production statistics, amounts of fertilizer applied to crops, and trends in manure management practices. This methodology is based on international guidelines developed by sector experts for preparing GHG emissions inventories.[63]

Data on crop production in Maryland from 1990 to 2005 and the number of animals in the state from 1990 to 2005 were obtained from the United States Department of Agriculture (USDA) National Agriculture Statistical Service (NASS) and incorporated as defaults in SIT.[64] The default SIT manure management system assumptions for each livestock category were used for this inventory. SIT data on fertilizer usage came from *Commercial Fertilizers*, a report from the Fertilizer Institute. Activity data for fertilizer includes all potential uses in addition to agriculture, such as residential and commercial (e.g., golf courses). The estimates are reported in the agriculture sector but they represent emissions occurring on other land uses.

Crop production data from USDA NASS were available through 2005; therefore, N_2O emissions from crop residues and crops that use nitrogen (i.e., nitrogen fixation) and N_2O and CH_4 emissions from agricultural residue burning were calculated through 2005. Emissions for the other agricultural crop production categories (i.e., synthetic and organic fertilizers) were also calculated through 2005. Data were not available to estimate nitrogen released by the cultivation of histosols (i.e., the number of acres of high organic content soils). Given that cultivation of organic soils is a source of CO_2 emissions in Maryland (see below), N_2O emissions are also probably occurring.

There is some agricultural residue burning conducted in Maryland; however, emissions are estimated to be relatively small (<0.01 million metric tons (MMt) of CO_2 equivalent (CO_2e)). The default SIT method was used to calculate emissions. The SIT methodology calculates emissions by multiplying the amount (e.g., bushels or tons) of each crop produced by a series of factors to calculate the amount of crop residue produced and burned, the resultant dry matter, and the carbon/nitrogen content of the dry matter.

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[62] GHG emissions were calculated using SIT, with reference to EIIP, Volume VIII: Chapter 8. "Methods for Estimating Greenhouse Gas Emissions from Livestock Manure Management", August 2004; Chapter 10. "Methods for Estimating Greenhouse Gas Emissions from Agricultural Soil Management", August 2004; and Chapter 11. "Methods for Estimating Greenhouse Gas Emissions from Field Burning of Agricultural Residues", August 2004.
[63] Revised 1996 1ntergovermental Panel on Climate Change (IPCC) Guidelines for National Greenhouse Gas Inventories, published by the National Greenhouse Gas Inventory Program of the IPCC, available at (http://www.ipcc-nggip.iges.or.jp/public/gl/invs1.htm; and Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories, published in 2000 by the National Greenhouse Gas Inventory Program of the IPCC, available at: (http://www.ipcc-nggip.iges.or.jp/public/gp/english/).
[64] USDA, NASS (http://www.nass.usda.gov/Statistics_by_State/Maryland/index.asp).

Emissions from enteric fermentation and manure management were projected based on forecasted animal populations. Dairy cattle forecasts were based on state-level projections of dairy cows from the Food and Agricultural Policy Research Institute (FAPRI).[65] Projections for all other livestock categories, except swine and sheep, were estimated based on linear forecasts of the historical 1990-2005 populations. The sheep population fluctuated greatly during the 1990-2005 period and linear projection results in a negative population at year 2020. Therefore, sheep population was projected based on the 1995-2005 historical data. The swine population showed a sharp decline in the late 1990s and early 2000s, and linear projection of the 1990-2005 populations result in negative populations before 2020. As a result, no growth is projected for the swine population after 2005. Livestock population growth rates are shown in Table F1.

Table F1. Growth Rates Applied for the Enteric Fermentation And Manure Management Categories

Livestock Category	2005-2020 Annual Growth
Dairy Cattle	-0.7%
Beef Cattle	0.3%
Swine	0%
Sheep	-9.2%
Goats	0.3%
Horses	-4.2%
Turkeys	2.9%
Layers	0.03%

Projections for agricultural burning and agricultural soils were based on linear extrapolation of the 1990-2005 historical data. Table F2 shows the 2005-2020 annual growth rates estimated for each category.

Table F2. Growth Rates Applied for the Agricultural Soils and Burning

Agricultural Category	2005-2020 Growth Rate
Agricultural Burning	0.1%
Agricultural Soils – Direct Emissions	
Fertilizers	2.9%
Crop Residues	0.3%
Nitrogen-Fixing Crops	0%
Histosols	0%
Livestock	-3.3%
Agricultural Soils – Indirect Emissions	
Fertilizers	2.9%
Livestock	-1.3%
Leaching/Runoff	1.3%

[65] FAPRI Agricultural Outlook 2006, Food and Agricultural Policy Research Institute, http://www.fapri.iastate.edu/outlook2006.

Soil Carbon

Net carbon fluxes from agricultural soils have been estimated by researchers at the Natural Resources Ecology Laboratory at Colorado State University and are reported in the US Inventory of Greenhouse Gas Emissions and Sinks[66] and the US Agriculture and Forestry Greenhouse Gas Inventory. The estimates are based on the Intergovernmental Panel on Climate Change (IPCC) methodology for soil carbon adapted to conditions in the US. Preliminary state-level estimates of CO_2 fluxes from mineral soils and emissions from the cultivation of organic soils were reported in the US Agriculture and Forestry Greenhouse Gas Inventory. Currently, these are the best available data at the state-level for this category. The inventory did not report state-level estimates of CO_2 emissions from limestone and dolomite applications; hence, this source is not included in this inventory at present.

Carbon dioxide fluxes resulting from specific management practices were reported. These practices include: conversions of cropland resulting in either higher or lower soil carbon levels; additions of manure; participation in the Federal Conservation Reserve Program (CRP); and cultivation of organic soils (with high organic carbon levels). For Maryland, Table F3 shows a summary of the latest estimates available from the USDA, which are for 1997.[67] These data show that changes in agricultural practices are estimated to result in net sequestration of 0.15 $MMtCO_2e$ per year (yr) in Maryland; this is driven largely by the amount of land conversions from cropland to hay or grazing land in Maryland. Since data are not yet available from USDA to make a determination of whether the emissions are increasing or decreasing, emissions of -0.15 $MMtCO_2e$/yr are assumed to remain constant.

Table F3. GHG Emissions from Soil Carbon Changes Due to Cultivation Practices ($MMtCO_2e$)

Changes in cropland			Changes in Hayland				Other			Total[4]
Plowout of grassland to annual cropland[1]	Cropland manage-ment	Other cropland[2]	Cropland converted to hayland[3]	Hayland manage-ment	Cropland converted to grazing land[3]	Grazing land manage-ment	CRP	Manure application	Cultivation of organic soils	Net soil carbon emissions
0.18	(0.04)	0.00	(0.15)	0.00	(0.07)	0.00	0.00	(0.08)	0.00	(0.15)

Based on USDA 1997 estimates. Parentheses indicate net sequestration.
[1] Losses from annual cropping systems due to plow-out of pastures, rangeland, hayland, set-aside lands, and perennial/horticultural cropland (annual cropping systems on mineral soils, e.g., corn, soybean, cotton, and wheat).
[2] Perennial/horticultural cropland and rice cultivation.
[3] Gains in soil carbon sequestration due to land conversions from annual cropland into hay or grazing land.
[4] Total does not include change in soil organic carbon storage on federal lands, including those that were previously under private ownership, and does not include carbon storage due to sewage sludge applications.

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[66] US Inventory of Greenhouse Gas Emissions and Sinks: 1990-2005 (and earlier editions), US Environmental Protection Agency, Report # 430-R-07-002, April 2007. Available at: http://www.epa.gov/climatechange/emissions/usinventoryreport.html.
[67] US Agriculture and Forestry Greenhouse Gas Inventory: 1990-2001. Global Change Program Office, Office of the Chief Economist, US Department of Agriculture. Technical Bulletin No. 1907, 164 pp. March 2004. http://www.usda.gov/oce/global_change/gg_inventory.htm; the data are in appendix B table B-11. The table contains two separate IPCC categories: "carbon stock fluxes in mineral soils" and "cultivation of organic soils." The latter is shown in the second to last column of Table F3. The sum of the first nine columns is equivalent to the mineral soils category.

Results

Figure F1 and Table F4 show gross GHG emissions associated with the agricultural sector from 1990 through 2020. In 1990, enteric fermentation accounted for about 22% (0.47 $MMtCO_2e$) of total agricultural emissions. Enteric fermentation emissions decreased to 0.35 $MMtCO_2e$ by 2005 (19% of total agricultural emissions) due to the decline in beef and dairy cattle populations between 1990 and 2005. While the beef cattle population is projected to increase slightly, this increase does not offset the decrease projected for the dairy cattle population, and enteric fermentation emissions are estimated to be 0.33 $MMtCO_2e$ in 2020.

The manure management category accounted for 16% (0.34 $MMtCO_2e$) of total agricultural emissions in 1990 and remained relatively unchanged at 17% (0.30 $MMtCO_2e$) in 2005. Manure management is projected to increase slightly to 0.32 $MMtCO_2e$ by 2020. This category stays relatively constant primarily due to the assumption of no growth in the swine population between 2005 and 2020.

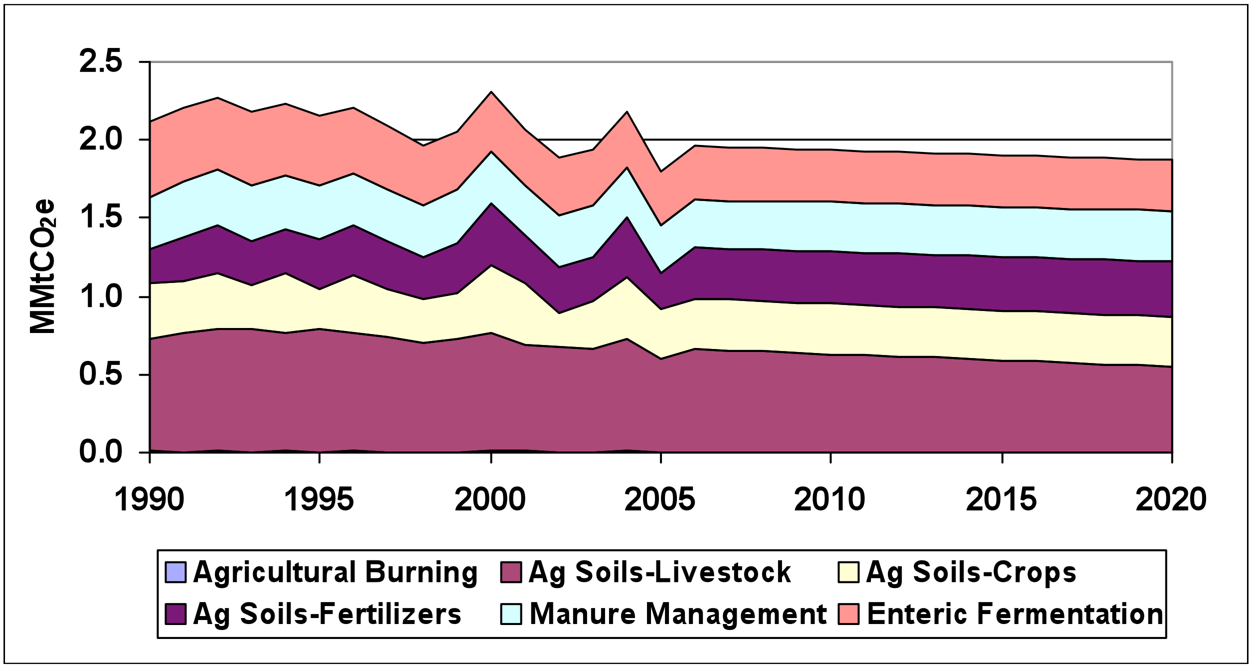
The largest source of emissions in the agricultural sector is the agricultural soils category, which includes crops (legumes and crop residues), cultivated histosols, fertilizer, manure application, and indirect sources (leaching, runoff, and atmospheric deposition). Agricultural soils stay relatively constant from 1990 to 2020, with 1990 emissions accounting for 61% (1.3 $MMtCO_2e$) of total agricultural emissions and 2020 emissions estimated to be about 65% (1.2 $MMtCO_2e$) of total agricultural emissions.

Agricultural burning emissions were estimated to be very small based on the SIT activity data (<0.01 $MMtCO_2e$/yr from 1990 to 2005). Emissions for this category account for about one-half of the national emissions included in the USDA Inventory which, relative to other agricultural categories, reports a low level of residue burning emissions (0.02 $MMtCO_2e$). Even though these emission estimates using the SIT are low relative to emissions associated with the other agricultural categories in Maryland, the emission estimates for agricultural burning in Maryland using the SIT methodology are inconsistent with other data and should be refined using actual activity data for Maryland, if available.

The only standard IPCC source categories missing from this report are CO_2 emissions from limestone and dolomite application and N_2O emissions from the cultivation of histosols. Estimates for limestone and dolomite application in Maryland were not available; however, the USDA's national estimate for soil liming is about 9 $MMtCO_2e$/yr.[68]

[68] US Agriculture and Forestry Greenhouse Gas Inventory: 1990-2001. Global Change Program Office, Office of the Chief Economist, US Department of Agriculture. Technical Bulletin No. 1907. 164 pp. March 2004.

Figure F1. Gross GHG Emissions from Agriculture



Source: CCS calculations based on approach described in text.
Notes: Agricultural soils – crops category includes: incorporation of crop residues and nitrogen fixing crops (no cultivation of histosols estimated); emissions for agricultural residue burning are too small to be seen in this chart.

Table F4. Gross GHG Emissions from Agriculture ($MMtCO_2e$)

Source	1990	1995	2000	2005	2010	2015	2020
Enteric Fermentation	0.475	0.452	0.375	0.349	0.331	0.329	0.327
Manure Management	0.340	0.343	0.332	0.303	0.320	0.320	0.320
Ag Soils-Fertilizers	0.217	0.317	0.399	0.232	0.331	0.344	0.357
Ag Soils-Crops	0.359	0.253	0.433	0.312	0.323	0.320	0.317
Ag Soils-Livestock	0.715	0.786	0.759	0.597	0.624	0.584	0.544
Agricultural Burning	0.006	0.005	0.008	0.006	0.006	0.006	0.006
TOTAL	**2.112**	**2.158**	**2.306**	**1.800**	**1.935**	**1.903**	**1.871**

Key Uncertainties

Emissions from enteric fermentation and manure management are dependent on the estimates of animal populations and the various factors used to estimate emissions for each animal type and manure management system (i.e., emission factors which are derived from several variables including manure production levels, volatile solids content, and CH_4 formation potential). Each of these factors has some level of uncertainty. Also, animal populations fluctuate throughout the year, and thus using point estimates introduces uncertainty into the average annual estimates of these populations. In addition, there is uncertainty associated with the original population survey methods employed by USDA. The largest contributors to uncertainty in emissions from manure management are the emission factors, which are derived from limited data sets.

As mentioned above, for emissions associated with changes in agricultural soil carbon levels, the only data currently available are for 1997. When newer data are released by the USDA, these should be reviewed to represent current conditions as well as to assess trends. In particular, given the potential for some CRP acreage to retire and possibly return to active cultivation prior to 2020, the emissions could be appreciably affected. As mentioned above, emission estimates for soil liming have not been developed for Maryland.

Another contributor to the uncertainty in the emission estimates is the forecast assumptions. The growth rates for most categories are assumed to continue growing at historical 1990-2005 growth rates.

Appendix G. Waste Management

Overview

Greenhouse gas (GHG) emissions from waste management include:

- Solid waste management – methane (CH_4) emissions from municipal and industrial solid waste landfills (LFs), accounting for CH_4 that is flared or captured for energy production (this includes both open and closed landfills);
- Solid waste combustion – CH_4, carbon dioxide (CO_2), and nitrous oxide (N_2O) emissions from the combustion of solid waste in incinerators or waste to energy plants, as well as from residential open burning; and
- Wastewater management – CH_4 and N_2O from municipal wastewater and CH_4 from industrial wastewater (WW) treatment facilities.

Inventory and Reference Case Projections

Solid Waste Management

For solid waste management, Center for Climate Strategies (CCS) used the United States Environmental Protection Agency's (US EPA) State Greenhouse Gas Inventory Tool (SIT) with landfill data provided by the Maryland Department of the Environment (MDE) to estimate emissions.[69] The landfill data provided by MDE included individual landfill information on landfill location (county), capacity, annual and average waste acceptance rates from 1990 through 2005, the year the landfill opened and the year the landfill closed or is expected to close, as well as control information. The MDE data indicate that 11 of the State's landfills are controlled--two with landfill gas to energy (LFGTE) plants, and nine with flares. The remaining 48 landfills throughout the state are uncontrolled. The total annual waste emplaced was summed separately for uncontrolled landfills, flared landfills, and LFGTE facilities for each year from 1990 through 2005.

CCS performed three different runs in SIT to estimate emissions from municipal solid waste (MSW) landfills: (1) uncontrolled landfills; (2) landfills with an LFGTE plant; and (3) landfills with a flare. For each of these three runs, the total annual waste emplaced at landfills in the specified control category for each year from 1990 through 2005 was entered as input to SIT. The SIT default waste emplacement rates were used for years from 1960 through 1989. SIT produced annual estimates of CH_4 emissions through 2005 for each of these landfill categories. CCS then performed post-processing of the landfill emissions to account for landfill gas controls (at LFGTE and flared sites) and to project the emissions through 2020.For the controlled landfills, CCS assumed that the overall CH_4 collection and control efficiency is 75%.[70]

[69] Walter A. Simms, Public Health Engineer, Air Quality Planning Division, Air and Radiation Management Administration, MDE, personal communication with M. Mullen, CCS, July, 2007.
[70] As per EPA's AP-42 Section on Municipal Solid Waste Landfills: http://www.epa.gov/ttn/chief/ap42/ch02/final/c02s04.pdf.

Growth rates were estimated by using the historic (1995-2005) growth rates of emissions in both the controlled and uncontrolled landfill categories. The period from 1995 to 2005 was used due to a large number of landfill closures in the US between 1985 and 1995 (which could have affected waste management practices). Hence, the post-1995 period is thought to be the most representative of the growth in waste emplacement rates and subsequent emissions. The annual growth rates are: -0.14% for uncontrolled sites, 0.28% for landfills with flares, and 1.7% for LFTGE facilities. The decrease in the uncontrolled category is due to smaller rates of waste emplacement at these sites in the post-1995 period.

CCS used the SIT default for industrial landfills. This default is based on national data indicating that industrial landfilled waste is emplaced at approximately 7% of the rate of MSW emplacement. Hence, the assumption is that this additional industrial waste emplacement occurs in addition to that already addressed in the emplacement rates for MSW sites. Due to a lack of data, no controls were assumed for industrial waste landfilling. For industrial landfills, the growth rate in emissions from 1995 to 2005 (0.15%/yr) was used to project emissions from 2006 to 2020.

Maryland is a net exporter of waste. While a small amount of waste is generally imported annually from Pennsylvania and West Virginia, a much larger amount of waste generated in Maryland is exported out of the state, on the order of 25%. CCS prepared an estimate of the emissions from the exported waste, based on MDE reports of the mass of MSW exported out of the state from 1999 through 2005. The amount of MSW exported in 1999 was assumed for all years prior to 1999. These waste emplacement values were entered in a separate SIT run, assuming all this waste was uncontrolled. The resulting uncontrolled emissions were then distributed in the same proportion as the results of the uncontrolled Maryland SIT runs, for uncontrolled landfills, flared sites, and LFTGE sites. For the controlled landfills, CCS assumed that the overall CH_4 collection and control efficiency is 75%, the same as for the in-state landfills, along with the assumption that 10% of CH_4 emissions are oxidized before being emitted to the atmosphere. Growth rates for these out-of-state emissions, by landfill type, were calculated based on the historic growth rate at these landfills from 1995 to 2005.

Solid Waste Combustion

Sources of solid waste combustion in Maryland include solid waste burning in municipal and medical waste incinerators and hazardous waste incineration. The SIT defaults were used to specify the amount of solid waste combusted from 1990-1998. For the years from 1999 to 2005, the amounts of waste combusted were obtained from MDE[71] and used as an input to SIT. The SIT default emission factors and waste characteristics were also used to estimate emissions from solid waste combustion. No information was identified on plans for additional plants in the future or expanded capacity at the existing plants, so emissions were held constant in the forecast years. As mentioned in the results section below, the emissions estimated for municipal waste combustors are captured in the energy supply sector; therefore, they have been left out of the emissions summaries for the waste management sector to avoid double-counting. The mass of wasted disposed of by incineration in Maryland may include a small amount of medical and

[71] Annual Report Solid Waste Management in Maryland 1999-2005, MDE: http://www.mde.state.md.us/ResearchCenter/Publications/Land/index.asp#solidwaste.

hazardous waste that would not have been captured in the energy supply sector. However, the amount of these wastes could not be separately quantified at this time.

Open burning of MSW at residential sites (e.g. backyard burn barrels) also contributes to GHG emissions. According to a Mid-Atlantic/Northeast Visibility Union (MANE-VU) report on open burning in residential areas, 62,404 tons of MSW was burned in Maryland in 2000.[72] This contributes to only 0.03 $MMtCO_2e$ in GHG emissions in 2000 based on SIT default waste characteristics and emission factors. Due to a lack of historical data from other years, it is assumed that open burning of MSW stays constant from 1990-2005. Emissions are held constant after 2005 due to uncertainty in the future levels of open burning activity.

Wastewater Management

GHG emissions from municipal and industrial wastewater treatment were also estimated. For municipal wastewater treatment, emissions were calculated in SIT based on state population, assumed biochemical oxygen demand (BOD) and protein consumption per capita, and emission factors for N_2O and CH_4. The key SIT default values are shown in Table G1. Municipal wastewater treatment emissions were projected based on the historical growth rate in these emissions in Maryland over the 1990-2005 time period. This leads to an annual growth rate of 1.25%.

Table G1. SIT Key Default Values for Municipal Wastewater Treatment

Variable	Value
BOD	0.09 kg /day-person
Amount of BOD anaerobically treated	16.25%
CH_4 emission factor	0.6 kg/kg BOD
MD residents not on septic	75%
Water treatment N_2O emission factor	4.0 g N_20/person-yr
Biosolids emission Factor	0.01 kg N_2O-N/kg sewage-N

Source: US EPA SIT – Wastewater Module; methodology and factors taken from US EPA, Emission Inventory Improvement Program, Volume 8, Chapter 12, October 1999: www.epa.gov/ttn/chief/eiip/techreport/volume08/.

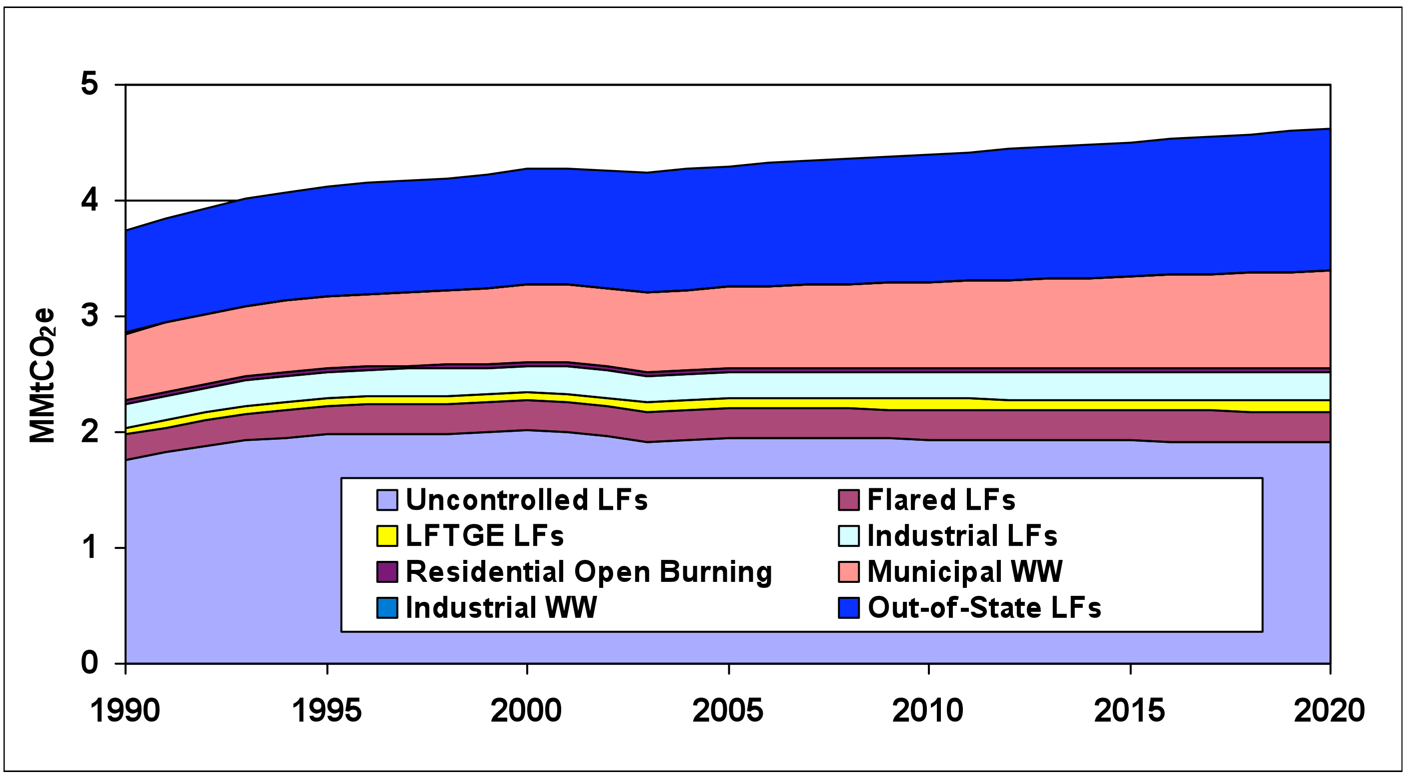
For industrial wastewater emissions, SIT provides default assumptions and emission factors for three industrial sectors: Fruits & Vegetables, Red Meat & Poultry, and Pulp & Paper. Default data for Red Meat & Poultry were used for Maryland, but the emissions are very small (about 0.001 $MMtCO_2e$ per year) and are not significant compared to the total waste sector emissions. No industrial wastewater treatment data were identified for the other two industrial sectors. Industrial wastewater emissions in the projection years were held constant at 2005 emission levels.

[72] Open Burning in Residential Areas, Emissions Inventory Development Report, MANE-VU, prepared by E. H. Pechan & Associates, Inc, January, 2004.

Results

Figure G1 and Table G2 show the resulting emission estimates for the waste management sector. Combustion emissions from solid waste combustion are captured in the energy supply sector. Therefore, these emissions are not included in the summaries here. Because the emissions resulting from MSW exported to landfills outside of Maryland should be captured in the emission inventories of the receiving states, these emissions are shown separately, outside the total of the in-state waste management emissions, in Table G2. Overall, the waste management sector accounts for 4.3 MMtCO_2e in 2005. By 2020, emissions are expected to increase slightly to 4.6 MMtCO_2e. In 2005, 45% of the emissions were contributed by the uncontrolled landfills sector, with another 24% contributed by out-of-state landfills. By 2020, the contribution from the uncontrolled in-state landfills is expected to decrease slightly to about 41%, while the out-of-state landfill emission contribution increases to 26%. Controlled landfills (flared sites) contributed 6% of total waste emissions in both 2005 and in 2020, while emissions at LFGTE landfill sites contributed about 2% of the waste management emissions in both 2005 and 2020. Industrial landfills contributed just over 5% of the waste management emissions in both 2005 and 2020.

Figure G1. Maryland GHG Emissions from Waste Management



Source: CCS calculations based on approach described in text.
Notes: LF – landfill; WW – wastewater.

Emissions from municipal wastewater are the third largest contributor to the waste management sector in Maryland. Municipal wastewater accounts for 16% of the waste management emissions in 2005, growing to 18% by 2020. Note that these estimates are based on the default parameters listed in Table G1 and might not adequately account for existing controls (e.g., anaerobic digesters served by a flare or other combustion device) or specific wastewater treatment methods in Maryland (e.g., anaerobic digestion versus aerobic digestion). As mentioned above, CCS modeled only emissions from Red Meat & Poultry processors in the industrial wastewater treatment sector. Approximately 0.03% of the emissions were contributed by the industrial wastewater treatment sector in both 2005 and 2020. Residential open burning accounts for the remaining 1% of emissions in 2005 and 2020.

Table G2. Maryland GHG Emissions from Waste Management (MMtCO₂e)

Source	1990	1995	2000	2005	2010	2015	2020
Uncontrolled LFs	1.77	1.98	2.01	1.95	1.94	1.92	1.91
Flared LFs	0.21	0.25	0.26	0.26	0.26	0.26	0.27
LFTGE LFs	0.06	0.07	0.07	0.08	0.09	0.10	0.11
Industrial LFs	0.20	0.23	0.23	0.23	0.23	0.23	0.24
Residential Open Burning	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Municipal WW	0.58	0.62	0.67	0.70	0.75	0.79	0.84
Industrial WW	0.002	0.001	0.001	0.001	0.001	0.001	0.001
Total	**2.86**	**3.18**	**3.27**	**3.26**	**3.30**	**3.35**	**3.40**
Out-of-State LFs	0.89	0.94	1.00	1.05	1.10	1.16	1.22
Total with Out-of-State LFs	**3.74**	**4.12**	**4.27**	**4.30**	**4.40**	**4.51**	**4.62**

Key Uncertainties

The methods used to model landfill gas emissions do not adequately account for the points in time when controls were applied at individual sites. Hence, for landfills, the historical emissions are less certain than current emissions and future emissions for this reason (since each site that is currently controlled was modeled as always being controlled, the historic emissions are low as a result). The modeling also does not account for uncontrolled sites that will need to apply controls during the period of analysis due to triggering requirements of the federal New Source Performance Standards/Emission Guidelines.

In addition to the inherent uncertainties in modeling CH_4 emissions from landfills, there are two important variables in adjusting these emissions to account for the amount emitted to the atmosphere. The first is the EPA assumption that 10% of the methane generated is oxidized in the surface layers of the landfill. There is little empirical evidence to assess the validity of this assumption, so it was not applied for this assessment. More importantly, for controlled sites, the EPA default assumption is that 75% of the methane is collected by the LFG collection system. Currently, this assumption is fairly contentious with estimates from differing entities ranging from 20% to 99%. EPA is currently planning studies using remote sensing techniques in an attempt to better address this issue. Several different factors affect the amount of LFG collected: landfill design, including whether the site is fully lined and capped, as well as the surrounding soil type; quality of the LFG collection system (e.g. proper siting of wells); and proper operation of the collection system (landfills are dynamic systems, so the LFG collection system must be continually monitored and adjusted to assure optimum collection efficiency; also, LFGTE site operators will try to optimize collection for gas quality (methane content) and have to balance quality versus overall collection efficiency.

In estimating emissions from the MSW exported out of Maryland, the assumption that the waste was emplaced in controlled versus uncontrolled landfills using the same mix as the Maryland waste contributes to uncertainty in this sector.

For industrial landfills, these were estimated using national defaults (7% of the rate of MSW emplacement). It could be that the available MSW emplacement data from MDE data used to model the MSW emissions already captures industrial LF waste emplacement. As with overall MSW landfill emissions, industrial landfill emissions are projected to increase between 2005 and 2020. Hence, the industrial landfill inventory and forecast has a significant level of uncertainty and should be investigated further. For example, the existence of active industrial landfills that are not already represented in the MDE landfills database should be determined.

For solid waste combustion, emissions from residential open burning are based only on data for the year 2000. Hence, historical and projected emissions from residential open burning contain a high level of uncertainty, however this subsector contributes relatively little to the GHG total.

For the wastewater sector, the key uncertainties are associated with the application of SIT default values for the parameters listed in Table G1 (e.g., fraction of the MD population on septic; fraction of BOD which is anaerobically decomposed). The SIT defaults were derived from national data. Hence, they may not adequately characterize the wastewater treatment processes currently employed or to be employed in the future.

Appendix H. Forestry & Land Use

Overview

Forestland emissions refer to the net carbon dioxide (CO_2) flux[73] from forested lands in Maryland, which account for about 43% of the state's land area.[74] The dominant forest type in Maryland is Oak-Hickory which makes up about 63% of forested lands. Other common forest types are Loblolly-shortleaf pine at 11% of forested land, and Oak-Pine at 10% of forested land. All other forest types make up less than 6% each of the state's forests.

Through photosynthesis, CO_2 is taken up by trees and plants and converted to carbon in biomass within the forests. Carbon dioxide emissions occur from respiration in live trees, decay of dead biomass, and combustion (both wildfires and biomass removed from forests for energy use). In addition, carbon is stored for long time periods when forest biomass is harvested for use in durable wood products. Carbon dioxide flux is the net balance of CO_2 removals from and emissions to the atmosphere from the processes described above.

The forestry sector CO_2 flux is categorized into two primary subsectors:

- *Forested Landscape*: this consists of carbon flux occurring on lands that are not part of the urban landscape. Fluxes covered include net carbon sequestration and carbon stored in harvested wood products (HWP) or landfills.
- *Urban Forestry and Land Use*: this covers carbon sequestration in urban trees, flux associated with carbon storage from landscape waste and food scraps in landfills, and nitrous oxide (N_2O) emissions from settlement soils (those occurring as a result of application of synthetic fertilizers).

Inventory and Reference Case Projections

Forested Landscape

For over a decade, the United States Forest Service (USFS) has been developing and refining a forest carbon modeling system for the purposes of estimating forest carbon inventories. The methodology is used to develop national forest CO_2 fluxes for the official *US Inventory of Greenhouse Gas Emissions and Sinks*. The national estimates are compiled from state-level data. The Maryland forest CO_2 flux data in this report come from the national analysis and are provided by the USFS. See the footnotes below for the most current documentation for the forest carbon modeling.[75] Additional forest carbon information is in the form of specific carbon conversion factors.[76]

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[73] "Flux" refers to both emissions of CO_2 to the atmosphere and removal (sinks) of CO_2 from the atmosphere.
[74] Total forested acreage is 2.7 million acres in 1997. Acreage by forest type available from the USFS at: http://www.fs.fed.us/ne/global/pubs/books/epa/states/MD.htm. The total land area in Maryland is 6.3 million acres (http://www.50states.com/maryland.htm).
[75] The most current citation for an overview of how the USFS calculates the inventory based forest carbon estimates as well as carbon in harvested wood products is from the *US Inventory of Greenhouse Gas Emissions and Sinks: 1990-2006* (and earlier editions), US Environmental Protection Agency, Report # USEPA #430-R-08-005, April 2008, available at: http://epa.gov/climatechange/emissions/usinventoryreport.html. Both Annex 3.12 and Chapter 7 are useful sources of reference. See also Smith, J.E., L.S. Heath, and M.C. Nichols (in press), *US Forest Carbon*

The forest CO_2 flux methodology relies on input data in the form of plot-level forest volume statistics from the Forest Inventory Analysis (FIA). FIA data on forest volumes are converted to values for ecosystem carbon stocks (i.e., the amount of carbon stored in forest carbon pools) using the FORCARB2 modeling system. Coefficients from FORCARB2 are applied to the plot level survey data to give estimates of C density [megagrams (Mg) per hectare] for a number of separate C pools. Additional background on the FORCARB system is provided in a number of publications.[77]

Carbon dioxide flux is estimated as the change in carbon mass for each carbon pool over a specified time-frame. Forest biomass data from at least two points in time are required. The change in carbon stocks between time intervals is estimated for specific carbon pools (Live Tree, Standing Dead Wood, Understory, Down & Dead Wood, Forest Floor, and Soil Organic Carbon) and divided by the number of years between inventory samples. Annual increases in carbon density reflect carbon sequestration in a specific pool; decreases in carbon density reveal CO_2 emissions or carbon transfers out of that pool (e.g., death of a standing tree transfers carbon from the live tree to standing dead wood pool). The amount of carbon in each pool is also influenced by changes in forest area (e.g., an increase in area could lead to an increase in the associated forest carbon pools and the estimated flux). The sum of carbon stock changes for all forest carbon pools yields a total net CO_2 flux for forest ecosystems.

In preparing these estimates, the USFS estimates the amount of forest carbon in different forest types as well as different carbon pools. The different forests also include differences in ownership class: those in the national forest (NF) system and those that are not federally-owned (private and other public forests). Additional details on the forest carbon inventory methods can be found in Annex 3 to the US EPA's GHG inventory for the US.[78]

Carbon pool data for three FIA cycles to estimate flux for two different periods were available for Maryland. The carbon pool data are shown in Table H1. These are the most recent USFS estimates available and will be included in EPA's latest national greenhouse gas (GHG) inventory. The underlying FIA data show a net decrease in forested area of 87,000 acres between 1990 and 1999 and a net increase in forested area of 74,000 acres in the 1990-2005 period. Most of the forested lands in Maryland are considered timberland, meaning that these are productive

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Calculation Tool User's Guide: Forestland Carbon Stocks and Net Annual Stock Change, Gen Tech Report, Newtown Square, PA: US Department of Agriculture, Forest Service, Northern Research Station.

[76] Smith, J.E., and L.S. Heath (2002). "A model of forest floor carbon mass for United States forest types," Res. Pap. NE-722. Newtown Square, PA: US Department of Agriculture, Forest Service, Northeastern Research Station. 37 p., or Jenkins, J.C., D.C. Chojnacky, L.S. Heath, R.A. Birdsey (2003), "National-scale biomass estimators for United States tree species", *Forest Science*, 49:12-35.

[77] Smith, J.E., L.S. Heath, and P.B. Woodbury (2004). "How to estimate forest carbon for large areas from inventory data", *Journal of Forestry*, 102: 25-31; Heath, L.S., J.E. Smith, and R.A. Birdsey (2003), "Carbon trends in US forest lands: A context for the role of soils in forest carbon sequestration", In J. M. Kimble, L. S. Heath, R. A. Birdsey, and R. Lal, editors. *The Potential of US Forest Soils to Sequester Carbon and Mitigate the Greenhouse Effect.* CRC Press, New York; and Woodbury, Peter B.; Smith, James E.; Heath, Linda S. 2007, "Carbon sequestration in the US forest sector from 1990 to 2010", *Forest Ecology and Management*, 241:14-27.

[78] Annex 3 to EPA's 2008 report, which contains estimates for calendar year 2005, can be downloaded at: http://epa.gov/climatechange/emissions/downloads/08_Annex_3.pdf.

forests. The timberland area is shown to increase by 112,000 acres between 1990 and 2005, which appears to be driving the total gain of 16 million metric tons (MMt) of carbon from forested areas during that period.

Table H1. USFS Forest Carbon Pool Data for Maryland

Forest Pool	1990 (MMtC)	1999 (MMtC)	2005 (MMtC)
Live Tree – Above Ground	77.8	80.9	91.9
Live Tree – Below Ground	15.0	15.6	17.7
Understory	2.2	2.1	2.2
Standing Dead	4.3	4.2	4.3
Down Dead	6.3	6.5	7.4
Forest Floor	14.4	15.0	13.8
Soil Carbon	68.6	67.1	67.1
Totals	**189**	**191**	**204**
Forest Area	**1990 (10^3 acres)**	**1999 (10^3 acres)**	**2005 (10^3 acres)**
All Forests	2,659	2,572	2,646
Timberland	2,407	2,374	2,519

Totals may not sum exactly due to independent rounding.

Data source: Smith, James, et al. *US Forest Carbon Calculation Tool: Forest-Land Carbon Stocks and Net Annual Stock Change* (http://www.nrs.fs.fed.us/pubs/2394), USFS, August 2007.

In addition to the forest carbon pools, additional carbon is stored in biomass removed from the forest for the production of HWP. Carbon remains stored in the durable wood products pool or is transferred to landfills where much of the carbon remains stored over a long period of time. The USFS uses a model referred to as WOODCARB2 for the purposes of modeling national HWP carbon storage.[79] State-level information for Maryland was provided to CCS by the USFS.[80]

As shown in Table H2, about 0.3 $MMtCO_2$ per year (yr) is estimated by the USFS to be sequestered annually (1999-2005) in wood products. Also, as shown in this table, the total flux estimate including all forest pools is -8.94 $MMtCO_2e$/yr.[81] This total includes a small net sink estimate for soil carbon (-0.05 $MMtCO_2$/yr). Note that from 1986 to 1999, soil carbon was considered a net source. Given the changes noted above in timberland, it appears that much of the negative carbon flux (sequestration) is from the increase in timberland between 1999 and 2005.

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[79] Skog, K.E., and G.A. Nicholson (1998), "Carbon cycling through wood products: the role of wood and paper products in carbon sequestration", *Forest Products Journal*, 48(7/8):75-83; or Skog, K.E., K. Pingoud, and J.E. Smith (2004), "A method countries can use to estimate changes in carbon stored in harvested wood products and the uncertainty of such estimates", *Environmental Management*, 33(Suppl. 1): S65-S73.
[80] Obtained from the Harvested Wood Product model developed by Ken Skog, USFS
[81] Jim Smith, USFS, *US Forest Carbon Calculation Tool: Forest-Land Carbon Stocks and Net Annual Stock Change* (http://www.nrs.fs.fed.us/pubs/2394), August 2007.

Table H2. USFS Annual Forest Carbon Fluxes for Maryland

Forest Pool	1986-1999 Flux (MMtC)	1999-2005 Flux (MMtC)	1986-1999 Flux ($MMtCO_2$)	1999-2005 Flux ($MMtCO_2$)
Forest Carbon Pools (non-soil)	-0.49	-2.34	-1.78	-8.60
Soil Organic Carbon	0.16	-0.01	0.60	-0.05
Harvested Wood Products	-0.08	-0.08	-0.30	-0.30
Forest Wildfires	0.00	0.00	0.01	0.01
Totals	**-0.40**	**-2.44**	**-1.48**	**-8.94**
Totals (excluding soil carbon)	**-0.57**	**-2.42**	**-2.08**	**-8.89**

Totals may not sum exactly due to independent rounding.

Data source: Smith, James, et al. US Forest Carbon Calculation Tool: Forest-Land Carbon Stocks and Net Annual Stock Change (http://www.nrs.fs.fed.us/pubs/2394), USFS, August 2007.

Data source for forest wildfires from the Maryland Department of Natural Resources (MDDNR) Forest Service under Wild Fire Acres Burned 2000-2006: http://www.dnr.state.md.us/forests/fire/index.asp.

Based on discussions with the USFS, CCS recommends excluding the soil carbon pool from the overall forest flux estimates due to high level of uncertainty associated with these estimates. The forest carbon flux estimates provided in the summary tables at the front of this report are those without the soil carbon pool.

For historic emission estimates, CCS used the 1986-1999 carbon flux to represent forest carbon flux prior to 1999. Current flux estimates (1999 to 2005) are those based on the USFS average for those years. For the reference case projections (2005-2020), the forest area and carbon densities of forestlands were assumed to remain at the same levels as in 2005. Information is not available on the near term effects of climate change and their impacts on forest productivity. Nor were data readily-available on projected losses in forested area.

Biomass burned in forest fires emits CO_2, methane (CH_4), and N_2O, in addition to many other gases and pollutants. Since CO_2 emissions are captured under total carbon flux calculations, CCS used the SIT to estimate CH_4 and N_2O emissions. CCS used state data (2000-2005) available from the Maryland Department of Natural Resources (MDDNR) Forest Service on the number of acres burned by forest type. An average of the 2000-2006 activity data was used for the years 1990-2005 and the forest type of "other temperate forests" was assumed in the SIT to calculate historical emissions. Projected emissions for 2005-2020 were assumed to be held constant at 2005 emissions.

Urban Forestry & Land Use

GHG emissions for 1990 through 2005 were estimated using the EPA SIT software and the methods provided in the Emission Inventory Improvement Program (EIIP) guidance document for the sector.[82] In general, the SIT methodology applies emission factors developed for the US to activity data for the urban forestry sector. Activity data include urban area, urban area with

[82] GHG emissions were calculated using SIT, with reference to EIIP, Volume VIII: Chapter 8.

tree cover, amount of landfilled yard trimmings and food scraps, and the total amount of synthetic fertilizer applied to settlement soils (e.g. parks, yards, etc.). This methodology is based on international guidelines developed by sector experts for preparing GHG emissions inventories.[83] Table H3 displays the emissions and reference case projections for Maryland.

Table H3. Urban Forestry Emissions and Reference Case Projections ($MMtCO_2e$)

Subsector	1990	2000	2005	2010	2020
Urban Trees	-1.20	-1.45	-1.58	-1.70	-1.95
Landfilled Yard Trimmings and Food Scraps	-4.51	-1.01	-1.08	-1.20	-1.34
N_2O from Settlement Soils	0.02	0.04	0.03	0.03	0.03
Total	**-5.69**	**-2.42**	**-2.62**	**-2.86**	**-3.27**

Data for settlement soils was obtained from AAPFCO (2006) Commercial Fertilizers 2005. Association of American Plant Food Control Officials and The Fertilizer Institute. University of Kentucky, Lexington, KY.

Changes in carbon stocks in urban trees are equivalent to tree growth minus biomass losses resulting from pruning and mortality. Net carbon sequestration was calculated using data on crown cover area. The default urban area data in SIT (which varied from 3,873 km^2 to 5,083 km^2 between 1990 and 2005) was multiplied by the state estimate of the percent of urban area with tree cover (40% for Maryland) to estimate the total area of urban tree cover. These default SIT urban area tree cover data represent area estimates taken from the US Census and coverage for years 1990 and 2000.[84] Estimates of urban area in the intervening years (1990-1999) and subsequent years (2001-2005) are interpolated and extrapolated, respectively.

Estimates of net carbon flux of landfilled yard trimmings and food scraps were calculated by estimating the change in landfill carbon stocks between inventory years. The SIT estimates for the amount of landfilled yard trimmings decreased significantly during the 1990's. CCS believes that this is consistent with changes in the waste management industry during this period. Therefore, the forecast was based on an extrapolation of the flux from 2000-2005, which show relatively constant rates of landfilling these materials.

Settlement soils include all developed land, transportation infrastructure and human settlements of any size. Projections for urban trees and settlement soils were based on linear extrapolation of the 1990-2005 historical data.

[83] Revised 1996 1ntergovermental Panel on Climate Change (IPCC) Guidelines for National Greenhouse Gas Inventories, published by the National Greenhouse Gas Inventory Program of the IPCC, available at (http://www.ipcc-nggip.iges.or.jp/public/gl/invs1.htm; and Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories, published in 2000 by the National Greenhouse Gas Inventory Program of the IPCC, available at: (http://www.ipcc-nggip.iges.or.jp/public/gp/english/).

[84] Dwyer, John F.; Nowak, David J.; Noble, Mary Heather; Sisinni, Susan M. 2000. Connecting people with ecosystems in the 21st century: an assessment of our nation's urban forests. Gen. Tech. Rep. PNW-GTR-490

Table H4 provides a summary of the estimated flux for the entire forestry and land use sector.

Table H4. Forestry and Land Use Flux and Reference Case Projections ($MMtCO_2e$)

	1990	2000	2005	2010	2020
Forested Landscape (excluding soil carbon)	-2.08	-8.89	-8.89	-8.89	-8.89
Urban Forestry and Land Use	-5.69	-2.42	-2.62	-2.86	-3.27
Sector Total	**-7.77**	**-11.31**	**-11.51**	**-11.75**	**-12.16**

Key Uncertainties

Emissions from wildfires in Maryland were estimated based on an average of acres burned from 2000-2006. 1990-1999 historic emissions were not available to give a better estimate. Future forecasts are hard to estimate given the large swings in fire activity from year to year. Emissions from wildfires in Maryland are very small, so they do not impact the estimated flux significantly.

It is important to note that there were methodological differences in the three FIA cycles (used to calculate carbon pools and flux) that can produce different estimates of forested area and carbon density. For example, the FIA program modified the definition of forest cover for the woodlands class of forestland (considered to be non-productive forests). Earlier FIA cycles defined woodlands as having a tree cover of at least 10%, while the newer sampling methods used a woodlands definition of tree cover of at least 5% (leading to more area being defined as woodland). In woodland areas, the earlier FIA surveys might not have inventoried trees of certain species or with certain tree form characteristics (leading to differences in both carbon density and forested acreage). Given that the forested land in Maryland is dominated by timberlands (productive forests), CCS does not believe that the definitional differences noted above have had a significant impact on the forest flux estimates provided in this report.

Also, FIA surveys since 1999 include all dead trees on the plots, but data prior to that are variable in terms of these data. The modifications to FIA surveys are a result of an expanded focus in the FIA program, which historically was only concerned with timber resources, while more recent surveys have aimed at a more comprehensive gathering of forest biomass data. In addition, the FIA program has moved from periodic to annual inventory methods. The effect of these changes in survey methods has not been estimated by the USFS.

Much of the urban forestry and land use emission estimates rely on national default data and could be improved with state-specific information.

Appendix I. Greenhouse Gases and Global Warming Potential Values: Excerpts from the Inventory of U.S. Greenhouse Emissions and Sinks: 1990-2000

Original Reference: Material for this Appendix is taken from the *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990 - 2000*, US Environmental Protection Agency, Office of Atmospheric Programs, EPA 430-R-02-003, April 2002 www.epa.gov/globalwarming/publications/emissions. Michael Gillenwater directed the preparation of this appendix.

Introduction

The *Inventory of U.S. Greenhouse Gas Emissions and Sinks* presents estimates by the United States government of US anthropogenic greenhouse gas emissions and removals for the years 1990 through 2000. The estimates are presented on both a full molecular mass basis and on a Global Warming Potential (GWP) weighted basis in order to show the relative contribution of each gas to global average radiative forcing.

The Intergovernmental Panel on Climate Change (IPCC) has recently updated the specific global warming potentials for most greenhouse gases in their Third Assessment Report (TAR, IPCC 2001). Although the GWPs have been updated, estimates of emissions presented in the US *Inventory* continue to use the GWPs from the Second Assessment Report (SAR). The guidelines under which the *Inventory* is developed, the *Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories* (IPCC/UNEP/OECD/IEA 1997) and the United Nations Framework Convention on Climate Change (UNFCCC) reporting guidelines for national inventories[85] were developed prior to the publication of the TAR. Therefore, to comply with international reporting standards under the UNFCCC, official emission estimates are reported by the United States using SAR GWP values. This excerpt of the US *Inventory* addresses in detail the differences between emission estimates using these two sets of GWPs. Overall, these revisions to GWP values do not have a significant effect on US emission trends.

Additional discussion on emission trends for the United States can be found in the complete *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2000*.

What is Climate Change?

Climate change refers to long-term fluctuations in temperature, precipitation, wind, and other elements of the Earth's climate system. Natural processes such as solar-irradiance variations, variations in the Earth's orbital parameters, and volcanic activity can produce variations in climate. The climate system can also be influenced by changes in the concentration of various gases in the atmosphere, which affect the Earth's absorption of radiation.

The Earth naturally absorbs and reflects incoming solar radiation and emits longer wavelength terrestrial (thermal) radiation back into space. On average, the absorbed solar radiation is balanced by the outgoing terrestrial radiation emitted to space. A portion of this terrestrial radiation, though, is itself absorbed by gases in the atmosphere. The energy from this absorbed terrestrial radiation warms the Earth's surface and atmosphere, creating what is known as the

[85] See FCCC/CP/1999/7 at www.unfccc.de

"natural greenhouse effect." Without the natural heat-trapping properties of these atmospheric gases, the average surface temperature of the Earth would be about 33°C lower (IPCC 2001).

Under the UNFCCC, the definition of climate change is "a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods." Given that definition, in its Second Assessment Report of the science of climate change, the IPCC concluded that:

> *Human activities are changing the atmospheric concentrations and distributions of greenhouse gases and aerosols. These changes can produce a radiative forcing by changing either the reflection or absorption of solar radiation, or the emission and absorption of terrestrial radiation (IPCC 1996).*

Building on that conclusion, the more recent IPCC Third Assessment Report asserts that "[c]oncentrations of atmospheric greenhouse gases and their radiative forcing have continued to increase as a result of human activities" (IPCC 2001).

The IPCC went on to report that the global average surface temperature of the Earth has increased by between 0.6 ± 0.2°C over the 20th century (IPCC 2001). This value is about 0.15°C larger than that estimated by the Second Assessment Report, which reported for the period up to 1994, "owing to the relatively high temperatures of the additional years (1995 to 2000) and improved methods of processing the data" (IPCC 2001).

While the Second Assessment Report concluded, "the balance of evidence suggests that there is a discernible human influence on global climate," the Third Assessment Report states the influence of human activities on climate in even starker terms. It concludes that, "[I]n light of new evidence and taking into account the remaining uncertainties, most of the observed warming over the last 50 years is likely to have been due to the increase in greenhouse gas concentrations" (IPCC 2001).

Greenhouse Gases

Although the Earth's atmosphere consists mainly of oxygen and nitrogen, neither plays a significant role in enhancing the greenhouse effect because both are essentially transparent to terrestrial radiation. The greenhouse effect is primarily a function of the concentration of water vapor, carbon dioxide, and other trace gases in the atmosphere that absorb the terrestrial radiation leaving the surface of the Earth (IPCC 1996). Changes in the atmospheric concentrations of these greenhouse gases can alter the balance of energy transfers between the atmosphere, space, land, and the oceans. A gauge of these changes is called radiative forcing, which is a simple measure of changes in the energy available to the Earth-atmosphere system (IPCC 1996). Holding everything else constant, increases in greenhouse gas concentrations in the atmosphere will produce positive radiative forcing (i.e., a net increase in the absorption of energy by the Earth).

Climate change can be driven by changes in the atmospheric concentrations of a number of radiatively active gases and aerosols. We have clear evidence that human activities have affected concentrations, distributions and life cycles of these gases (IPCC 1996).

Naturally occurring greenhouse gases include water vapor, carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), and ozone (O_3). Several classes of halogenated substances that contain fluorine, chlorine, or bromine are also greenhouse gases, but they are, for the most part, solely a product of industrial activities. Chlorofluorocarbons (CFCs) and hydrochlorofluorocarbons (HCFCs) are halocarbons that contain chlorine, while halocarbons that contain bromine are referred to as bromofluorocarbons (i.e., halons). Because CFCs, HCFCs, and halons are stratospheric ozone depleting substances, they are covered under the Montreal Protocol on Substances that Deplete the Ozone Layer. The UNFCCC defers to this earlier international treaty; consequently these gases are not included in national greenhouse gas inventories. Some other fluorine containing halogenated substances—hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF_6)—do not deplete stratospheric ozone but are potent greenhouse gases. These latter substances are addressed by the UNFCCC and accounted for in national greenhouse gas inventories.

There are also several gases that, although they do not have a commonly agreed upon direct radiative forcing effect, do influence the global radiation budget. These tropospheric gases—referred to as ambient air pollutants—include carbon monoxide (CO), nitrogen dioxide (NO_2), sulfur dioxide (SO_2), and tropospheric (ground level) ozone (O_3). Tropospheric ozone is formed by two precursor pollutants, volatile organic compounds (VOCs) and nitrogen oxides (NO_x) in the presence of ultraviolet light (sunlight). Aerosols—extremely small particles or liquid droplets—often composed of sulfur compounds, carbonaceous combustion products, crustal materials and other human induced pollutants—can affect the absorptive characteristics of the atmosphere. However, the level of scientific understanding of aerosols is still very low (IPCC 2001).

Carbon dioxide, methane, and nitrous oxide are continuously emitted to and removed from the atmosphere by natural processes on Earth. Anthropogenic activities, however, can cause additional quantities of these and other greenhouse gases to be emitted or sequestered, thereby changing their global average atmospheric concentrations. Natural activities such as respiration by plants or animals and seasonal cycles of plant growth and decay are examples of processes that only cycle carbon or nitrogen between the atmosphere and organic biomass. Such processes—except when directly or indirectly perturbed out of equilibrium by anthropogenic activities—generally do not alter average atmospheric greenhouse gas concentrations over decadal timeframes. Climatic changes resulting from anthropogenic activities, however, could have positive or negative feedback effects on these natural systems. Atmospheric concentrations of these gases, along with their rates of growth and atmospheric lifetimes, are presented in Table 10.

Table 10. Global Atmospheric Concentration (ppm Unless Otherwise Specified), Rate of Concentration Change (ppb/year) and Atmospheric Lifetime (Years) of Selected Greenhouse Gases

Atmospheric Variable	CO_2	CH_4	N_2O	SF_6[a]	CF_4[a]
Pre-industrial atmospheric concentration	278	0.700	0.270	0	40
Atmospheric concentration (1998)	365	1.745	0.314	4.2	80
Rate of concentration change[b]	1.5[c]	0.007[c]	0.0008	0.24	1.0
Atmospheric Lifetime	50-200[d]	12[e]	114[e]	3,200	>50,000

Source: IPCC (2001)
[a] Concentrations in parts per trillion (ppt) and rate of concentration change in ppt/year.
[b] Rate is calculated over the period 1990 to 1999.
[c] Rate has fluctuated between 0.9 and 2.8 ppm per year for CO_2 and between 0 and 0.013 ppm per year for CH4 over the period 1990 to 1999.
[d] No single lifetime can be defined for CO_2 because of the different rates of uptake by different removal processes.
[e] This lifetime has been defined as an "adjustment time" that takes into account the indirect effect of the gas on its own residence time.

A brief description of each greenhouse gas, its sources, and its role in the atmosphere is given below. The following section then explains the concept of Global Warming Potentials (GWPs), which are assigned to individual gases as a measure of their relative average global radiative forcing effect.

Water Vapor (H_2O). Overall, the most abundant and dominant greenhouse gas in the atmosphere is water vapor. Water vapor is neither long-lived nor well mixed in the atmosphere, varying spatially from 0 to 2 percent (IPCC 1996). In addition, atmospheric water can exist in several physical states including gaseous, liquid, and solid. Human activities are not believed to directly affect the average global concentration of water vapor; however, the radiative forcing produced by the increased concentrations of other greenhouse gases may indirectly affect the hydrologic cycle. A warmer atmosphere has an increased water holding capacity; yet, increased concentrations of water vapor affects the formation of clouds, which can both absorb and reflect solar and terrestrial radiation. Aircraft contrails, which consist of water vapor and other aircraft emittants, are similar to clouds in their radiative forcing effects (IPCC 1999).

Carbon Dioxide (CO_2). In nature, carbon is cycled between various atmospheric, oceanic, land biotic, marine biotic, and mineral reservoirs. The largest fluxes occur between the atmosphere and terrestrial biota, and between the atmosphere and surface water of the oceans. In the atmosphere, carbon predominantly exists in its oxidized form as CO_2. Atmospheric carbon dioxide is part of this global carbon cycle, and therefore its fate is a complex function of geochemical and biological processes. Carbon dioxide concentrations in the atmosphere increased from approximately 280 parts per million by volume (ppmv) in pre-industrial times to 367 ppmv in 1999, a 31 percent increase (IPCC 2001). The IPCC notes that "[t]his concentration has not been exceeded during the past 420,000 years, and likely not during the past 20 million years. The rate of increase over the past century is unprecedented, at least during the past 20,000 years." The IPCC definitively states that "the present atmospheric CO_2 increase is caused by anthropogenic emissions of CO_2" (IPCC 2001). Forest clearing, other biomass burning, and some non-energy production processes (e.g., cement production) also emit notable quantities of carbon dioxide.

In its second assessment, the IPCC also stated that "[t]he increased amount of carbon dioxide [in the atmosphere] is leading to climate change and will produce, on average, a global warming of the Earth's surface because of its enhanced greenhouse effect—although the magnitude and significance of the effects are not fully resolved" (IPCC 1996).

Methane (CH_4). Methane is primarily produced through anaerobic decomposition of organic matter in biological systems. Agricultural processes such as wetland rice cultivation, enteric fermentation in animals, and the decomposition of animal wastes emit CH_4, as does the decomposition of municipal solid wastes. Methane is also emitted during the production and distribution of natural gas and petroleum, and is released as a by-product of coal mining and incomplete fossil fuel combustion. Atmospheric concentrations of methane have increased by about 150 percent since pre-industrial times, although the rate of increase has been declining. The IPCC has estimated that slightly more than half of the current CH_4 flux to the atmosphere is anthropogenic, from human activities such as agriculture, fossil fuel use and waste disposal (IPCC 2001).

Methane is removed from the atmosphere by reacting with the hydroxyl radical (OH) and is ultimately converted to CO_2. Minor removal processes also include reaction with Cl in the marine boundary layer, a soil sink, and stratospheric reactions. Increasing emissions of methane reduce the concentration of OH, a feedback which may increase methane's atmospheric lifetime (IPCC 2001).

Nitrous Oxide (N_2O). Anthropogenic sources of N_2O emissions include agricultural soils, especially the use of synthetic and manure fertilizers; fossil fuel combustion, especially from mobile combustion; adipic (nylon) and nitric acid production; wastewater treatment and waste combustion; and biomass burning. The atmospheric concentration of nitrous oxide (N_2O) has increased by 16 percent since 1750, from a pre industrial value of about 270 ppb to 314 ppb in 1998, a concentration that has not been exceeded during the last thousand years. Nitrous oxide is primarily removed from the atmosphere by the photolytic action of sunlight in the stratosphere.

Ozone (O_3). Ozone is present in both the upper stratosphere, where it shields the Earth from harmful levels of ultraviolet radiation, and at lower concentrations in the troposphere, where it is the main component of anthropogenic photochemical "smog." During the last two decades, emissions of anthropogenic chlorine and bromine-containing halocarbons, such as chlorofluorocarbons (CFCs), have depleted stratospheric ozone concentrations. This loss of ozone in the stratosphere has resulted in negative radiative forcing, representing an indirect effect of anthropogenic emissions of chlorine and bromine compounds (IPCC 1996). The depletion of stratospheric ozone and its radiative forcing was expected to reach a maximum in about 2000 before starting to recover, with detection of such recovery not expected to occur much before 2010 (IPCC 2001).

The past increase in tropospheric ozone, which is also a greenhouse gas, is estimated to provide the third largest increase in direct radiative forcing since the pre-industrial era, behind CO_2 and CH_4. Tropospheric ozone is produced from complex chemical reactions of volatile organic compounds mixing with nitrogen oxides (NO_x) in the presence of sunlight. Ozone, carbon monoxide (CO), sulfur dioxide (SO_2), nitrogen dioxide (NO_2) and particulate matter are included in the category referred to as "criteria pollutants" in the United States under the Clean Air Act and its subsequent amendments. The tropospheric concentrations of ozone and these other pollutants are short-lived and, therefore, spatially variable.

Halocarbons, Perfluorocarbons, and Sulfur Hexafluoride (SF_6). Halocarbons are, for the most part, man-made chemicals that have both direct and indirect radiative forcing effects. Halocarbons that contain chlorine—chlorofluorocarbons (CFCs), hydrochlorofluorocarbons (HCFCs), methyl chloroform, and carbon tetrachloride—and bromine—halons, methyl bromide, and hydrobromofluorocarbons (HBFCs)—result in stratospheric ozone depletion and are therefore controlled under the Montreal Protocol on Substances that Deplete the Ozone Layer. Although CFCs and HCFCs include potent global warming gases, their net radiative forcing effect on the atmosphere is reduced because they cause stratospheric ozone depletion, which is itself an important greenhouse gas in addition to shielding the Earth from harmful levels of ultraviolet radiation. Under the Montreal Protocol, the United States phased out the production and importation of halons by 1994 and of CFCs by 1996. Under the Copenhagen Amendments to the Protocol, a cap was placed on the production and importation of HCFCs by non-Article 5 countries beginning in 1996, and then followed by a complete phase-out by the year 2030. The ozone depleting gases covered under the Montreal Protocol and its Amendments are not covered by the UNFCCC.

Hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF_6) are not ozone depleting substances, and therefore are not covered under the Montreal Protocol. They are, however, powerful greenhouse gases. HFCs—primarily used as replacements for ozone depleting substances but also emitted as a by-product of the HCFC-22 manufacturing process—currently have a small aggregate radiative forcing impact; however, it is anticipated that their contribution to overall radiative forcing will increase (IPCC 2001). PFCs and SF_6 are predominantly emitted from various industrial processes including aluminum smelting, semiconductor manufacturing, electric power transmission and distribution, and magnesium casting. Currently, the radiative forcing impact of PFCs and SF_6 is also small; however, they have a significant growth rate, extremely long atmospheric lifetimes, and are strong absorbers of infrared radiation, and therefore have the potential to influence climate far into the future (IPCC 2001).

Carbon Monoxide (CO). Carbon monoxide has an indirect radiative forcing effect by elevating concentrations of CH_4 and tropospheric ozone through chemical reactions with other atmospheric constituents (e.g., the hydroxyl radical, OH) that would otherwise assist in destroying CH_4 and tropospheric ozone. Carbon monoxide is created when carbon-containing fuels are burned incompletely. Through natural processes in the atmosphere, it is eventually oxidized to CO_2. Carbon monoxide concentrations are both short-lived in the atmosphere and spatially variable.

Nitrogen Oxides (NO_x). The primary climate change effects of nitrogen oxides (i.e., NO and NO_2) are indirect and result from their role in promoting the formation of ozone in the troposphere and, to a lesser degree, lower stratosphere, where it has positive radiative forcing effects. Additionally, NO_x emissions from aircraft are also likely to decrease methane concentrations, thus having a negative radiative forcing effect (IPCC 1999). Nitrogen oxides are created from lightning, soil microbial activity, biomass burning – both natural and anthropogenic fires – fuel combustion, and, in the stratosphere, from the photo-degradation of nitrous oxide (N_2O). Concentrations of NO_x are both relatively short-lived in the atmosphere and spatially variable.

Nonmethane Volatile Organic Compounds (NMVOCs). Nonmethane volatile organic compounds include compounds such as propane, butane, and ethane. These compounds participate, along with NO_x, in the formation of tropospheric ozone and other photochemical oxidants. NMVOCs are emitted primarily from transportation and industrial processes, as well as biomass burning and non-industrial consumption of organic solvents. Concentrations of NMVOCs tend to be both short-lived in the atmosphere and spatially variable.

Aerosols. Aerosols are extremely small particles or liquid droplets found in the atmosphere. They can be produced by natural events such as dust storms and volcanic activity, or by anthropogenic processes such as fuel combustion and biomass burning. They affect radiative forcing in both direct and indirect ways: directly by scattering and absorbing solar and thermal infrared radiation; and indirectly by increasing droplet counts that modify the formation, precipitation efficiency, and radiative properties of clouds. Aerosols are removed from the atmosphere relatively rapidly by precipitation. Because aerosols generally have short atmospheric lifetimes, and have concentrations and compositions that vary regionally, spatially, and temporally, their contributions to radiative forcing are difficult to quantify (IPCC 2001).

The indirect radiative forcing from aerosols is typically divided into two effects. The first effect involves decreased droplet size and increased droplet concentration resulting from an increase in airborne aerosols. The second effect involves an increase in the water content and lifetime of clouds due to the effect of reduced droplet size on precipitation efficiency (IPCC 2001). Recent research has placed a greater focus on the second indirect radiative forcing effect of aerosols.

Various categories of aerosols exist, including naturally produced aerosols such as soil dust, sea salt, biogenic aerosols, sulphates, and volcanic aerosols, and anthropogenically manufactured aerosols such as industrial dust and carbonaceous aerosols (e.g., black carbon, organic carbon) from transportation, coal combustion, cement manufacturing, waste incineration, and biomass burning.

The net effect of aerosols is believed to produce a negative radiative forcing effect (i.e., net cooling effect on the climate), although because they are short-lived in the atmosphere—lasting days to weeks—their concentrations respond rapidly to changes in emissions. Locally, the negative radiative forcing effects of aerosols can offset the positive forcing of greenhouse gases (IPCC 1996). "However, the aerosol effects do not cancel the global-scale effects of the much longer-lived greenhouse gases, and significant climate changes can still result" (IPCC 1996).

The IPCC's Third Assessment Report notes that "the indirect radiative effect of aerosols is now understood to also encompass effects on ice and mixed-phase clouds, but the magnitude of any such indirect effect is not known, although it is likely to be positive" (IPCC 2001). Additionally, current research suggests that another constituent of aerosols, elemental carbon, may have a positive radiative forcing (Jacobson 2001). The primary anthropogenic emission sources of elemental carbon include diesel exhaust, coal combustion, and biomass burning.

Global Warming Potentials

Global Warming Potentials (GWPs) are intended as a quantified measure of the globally averaged relative radiative forcing impacts of a particular greenhouse gas. It is defined as the cumulative radiative forcing—both direct and indirect effects—integrated over a period of time from the emission of a unit mass of gas relative to some reference gas (IPCC 1996). Carbon dioxide (CO_2) was chosen as this reference gas. Direct effects occur when the gas itself is a greenhouse gas. Indirect radiative forcing occurs when chemical transformations involving the original gas produce a gas or gases that are greenhouse gases, or when a gas influences other radiatively important processes such as the atmospheric lifetimes of other gases. The relationship between gigagrams (Gg) of a gas and Tg CO_2 Eq. can be expressed as follows:

$$\text{Tg CO}_2\text{ Eq} = (\text{Gg of gas}) \times (\text{GWP}) \times \left(\frac{\text{Tg}}{1{,}000\text{ Gg}}\right) \text{where,}$$

Tg CO_2 Eq. = Teragrams of Carbon Dioxide Equivalents
Gg = Gigagrams (equivalent to a thousand metric tons)
GWP = Global Warming Potential
Tg = Teragrams

GWP values allow policy makers to compare the impacts of emissions and reductions of different gases. According to the IPCC, GWPs typically have an uncertainty of roughly ±35 percent, though some GWPs have larger uncertainty than others, especially those in which lifetimes have not yet been ascertained. In the following decision, the parties to the UNFCCC have agreed to use consistent GWPs from the IPCC Second Assessment Report (SAR), based upon a 100 year time horizon, although other time horizon values are available (see Table 11).

> *In addition to communicating emissions in units of mass, Parties may choose also to use global warming potentials (GWPs) to reflect their inventories and projections in carbon dioxide-equivalent terms, using information provided by the Intergovernmental Panel on Climate Change (IPCC) in its Second Assessment Report. Any use of GWPs should be based on the effects of the greenhouse gases over a 100-year time horizon. In addition, Parties may also use other time horizons. (FCCC/CP/1996/15/Add.1)*

Greenhouse gases with relatively long atmospheric lifetimes (e.g., CO_2, CH_4, N_2O, HFCs, PFCs, and SF_6) tend to be evenly distributed throughout the atmosphere, and consequently global average concentrations can be determined. The short-lived gases such as water vapor, carbon monoxide, tropospheric ozone, other ambient air pollutants (e.g., NO_x, and NMVOCs), and tropospheric aerosols (e.g., SO_2 products and black carbon), however, vary spatially, and consequently it is difficult to quantify their global radiative forcing impacts. GWP values are generally not attributed to these gases that are short-lived and spatially inhomogeneous in the atmosphere.

Table 11. Global Warming Potentials (GWP) and Atmospheric Lifetimes (Years) Used in the Inventory

Gas	Atmospheric Lifetime	100-year GWP[a]	20-year GWP	500-year GWP
Carbon dioxide (CO_2)	50-200	1	1	1
Methane (CH_4)[b]	12±3	21	56	6.5
Nitrous oxide (N_2O)	120	310	280	170
HFC-23	264	11,700	9,100	9,800
HFC-125	32.6	2,800	4,600	920
HFC-134a	14.6	1,300	3,400	420
HFC-143a	48.3	3,800	5,000	1,400
HFC-152a	1.5	140	460	42
HFC-227ea	36.5	2,900	4,300	950
HFC-236fa	209	6,300	5,100	4,700
HFC-4310mee	17.1	1,300	3,000	400
CF_4	50,000	6,500	4,400	10,000
C_2F_6	10,000	9,200	6,200	14,000
C_4F_{10}	2,600	7,000	4,800	10,100
C_6F_{14}	3,200	7,400	5,000	10,700
SF_6	3,200	23,900	16,300	34,900

Source: IPCC (1996)
[a] GWPs used here are calculated over 100 year time horizon
[b] The methane GWP includes the direct effects and those indirect effects due to the production of tropospheric ozone and stratospheric water vapor. The indirect effect due to the production of CO_2 is not included.

Table 12 presents direct and net (i.e., direct and indirect) GWPs for ozone-depleting substances (ODSs). Ozone-depleting substances directly absorb infrared radiation and contribute to positive radiative forcing; however, their effect as ozone-depleters also leads to a negative radiative forcing because ozone itself is a potent greenhouse gas. There is considerable uncertainty regarding this indirect effect; therefore, a range of net GWPs is provided for ozone depleting substances.

Table 12. Net 100-year Global Warming Potentials for Select Ozone Depleting Substances*

Gas	Direct	Net_{min}	Net_{max}
CFC-11	4,600	(600)	3,600
CFC-12	10,600	7,300	9,900
CFC-113	6,000	2,200	5,200
HCFC-22	1,700	1,400	1,700
HCFC-123	120	20	100
HCFC-124	620	480	590
HCFC-141b	700	(5)	570
HCFC-142b	2,400	1,900	2,300
$CHCl_3$	140	(560)	0
CCl_4	1,800	(3,900)	660
CH_3Br	5	(2,600)	(500)
Halon-1211	1,300	(24,000)	(3,600)
Halon-1301	6,900	(76,000)	(9,300)

Source: IPCC (2001)
* Because these compounds have been shown to deplete stratospheric ozone, they are typically referred to as ozone depleting substances (ODSs). However, they are also potent greenhouse gases. Recognizing the harmful effects of these compounds on the ozone layer, in 1987 many governments signed the *Montreal Protocol on Substances that Deplete the Ozone Layer* to limit the production and importation of a number of CFCs and other halogenated compounds. The United States furthered its commitment to phase-out ODSs by signing and ratifying the Copenhagen Amendments to the *Montreal Protocol* in 1992. Under these amendments, the United States committed to ending the production and importation of halons by 1994, and CFCs by 1996. The IPCC Guidelines and the UNFCCC do not include reporting instructions for estimating emissions of ODSs because their use is being phased-out under the *Montreal Protocol*. The effects of these compounds on radiative forcing are not addressed here.

The IPCC recently published its Third Assessment Report (TAR), providing the most current and comprehensive scientific assessment of climate change (IPCC 2001). Within that report, the GWPs of several gases were revised relative to the IPCC's Second Assessment Report (SAR) (IPCC 1996), and new GWPs have been calculated for an expanded set of gases. Since the SAR, the IPCC has applied an improved calculation of CO_2 radiative forcing and an improved CO_2 response function (presented in WMO 1999). The GWPs are drawn from WMO (1999) and the SAR, with updates for those cases where new laboratory or radiative transfer results have been published. Additionally, the atmospheric lifetimes of some gases have been recalculated. Because the revised radiative forcing of CO_2 is about 12 percent lower than that in the SAR, the GWPs of the other gases relative to CO_2 tend to be larger, taking into account revisions in lifetimes. However, there were some instances in which other variables, such as the radiative efficiency or the chemical lifetime, were altered that resulted in further increases or decreases in particular GWP values. In addition, the values for radiative forcing and lifetimes have been calculated for a variety of halocarbons, which were not presented in the SAR. The changes are described in the TAR as follows:

New categories of gases include fluorinated organic molecules, many of which are ethers that are proposed as halocarbon substitutes. Some of the GWPs have larger uncertainties than that of others, particularly for those gases where detailed laboratory data on lifetimes are not yet available. The direct GWPs have been calculated relative to CO_2 using an improved calculation of the CO_2 radiative forcing, the SAR response function for a CO_2 pulse, and new values for the radiative forcing and lifetimes for a number of halocarbons

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Appendix D

Maryland Climate Action Plan

Greenhouse Gas & Carbon Mitigation Working Group

Policy Option Documents

Contents

Maryland Climate Action Plan

Appendix D-1

Agriculture, Forestry & Waste Management

Agriculture, Forestry, and Waste Management

Introduction

The benefits of forests and trees are extensive, complex, and beyond measure. Trees remove carbon dioxide (CO_2) from the air and store carbon (C) in their trunks and branches; trees absorb and filter nitrogen dioxide (NO_2), sulfur dioxide (SO_2), ozone (O_3), carbon monoxide (CO), and particulate matter; trees release oxygen and intercept rainwater and dust. The process of evapotranspiration 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 greenhouse gases (GHGs) 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 GHGs from manufacturing plants, transportation, and heavy equipment. Shade and lower surface temperatures reduce the evaporation of chemicals from car engines, and reduce the need for air conditioning in cars. This reduces the amount of fuel burned and 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 GHGs and carbon sequestration. Additionally, these forests serve as the preferred land use for avoiding emissions. In the face of climate change, it is critical that everything possible is done to increase the amount of, and enhance the condition of forests and trees everywhere. Healthy forests and trees are our single most cost-effective tool for mitigating for climate change.

Summary List of Recommended Priority Policy Options for Analysis

Option No.	Policy Option	GHG Reductions ($MMtCO_2e$)			Net Present Value 2008–2020 (Million $)	Cost-Effective-ness ($/tCO_2e$)	Level of Support
		2012	2020	Total 2008–2020			
AFW-1	Forest Management for Enhanced Carbon Sequestration*	0.04	0.09	0.66	$89.10	$135	Unanimous
AFW-2	Managing Urban Trees and Forests for Greenhouse Gas (GHG) Benefits*	0.73	1.90	13.27	–$2,017.00	–$152	Unanimous
AFW-3	Afforestation, Reforestation, and Restoration of Forests and Wetlands						Unanimous
	Afforestation	0.21	0.6	3.9	$112.70	$29	
	Riparian areas	0.01	0.05	0.25	$11.00	$44	
AFW-4	Protection and Conservation of Agricultural Land, Coastal Wetlands, and Forested Land						Unanimous
	Agricultural land	0.11	0.28	1.93	$168.60	$87	
	Coastal Wetlands	N/Q	N/Q	N/Q	N/Q	N/Q	
	Forested land	2.2	2.7	30.5	$1,128.7	$37	
AFW-5	"Buy Local" Programs for Sustainable Agriculture, Wood, and Wood Products						Unanimous
	Farmers' Market	0.01	0.03	0.20	–$33.10	–$167	
	Local Produce	N/Q	N/Q	N/Q	N/Q	N/Q	
	Locally Grown and Processed Lumber	N/Q	N/Q	N/Q	N/Q	N/Q	
AFW-6	Expanded Use of Forest and Farm Feedstocks and By-Products for Energy Production						Unanimous
	Biomass (Including Agricultural Residue, Forest Feedstocks, and Energy Crops)	0.12	0.50	2.83	$34.10	$12	
	Methane (CH_4) Utilization From Livestock Manure and Poultry Litter	0.01	0.04	0.25	$0.06	$0.2	
AFW-7	In-State Liquid Biofuels Production						Unanimous
	Ethanol	*Study presented for informational purposes only*					
	Bio-diesel	0.10	0.17	1.41	$10.50	$7	
AFW-8	Nutrient Trading With Carbon Benefits	0.05	0.14	0.99	–$29.70	–$30	Unanimous
AFW-9	Waste Management Through Source Reduction (SR) and Advanced Recycling	8.80	29.27	184.00	–$1,118	–$6	Unanimous
	Sector Totals	**12.39**	**35.77**	**240.19**	**-$1643.04**	**–$7**	
	Sector Total After Adjusting for Overlaps†	**5.62**	**7.53**	**83.48**	**–$159.96**	**-$2**	
	Reductions From Recent Actions	**–**	**–**	**–**	**–**	**–**	
	Sector Total Plus Recent Actions	**–**	**–**	**–**	**–**	**–**	

GHG = greenhouse gas; $MMtCO_2e$ = million metric tons of carbon dioxide equivalent; $/$tCO_2e$ = dollars per metric ton of carbon dioxide equivalent; N/Q = not quantified; CH_4 = methane; SR = source reduction.

Note that negative costs represent a monetary savings.

* With Mitigation of Forest Loss Due to Insects, Disease, Pests, and Invasive Species

† See next page for discussion of overlap adjustments.

Overlap Discussion

The amount of CO_2 emissions reduced or sequestered in the policy options within the Agriculture, Forestry, and Waste Management (AFW) sector overlaps with some of the quantified benefits and costs of policy options within other sectors. Those overlaps were identified and adjusted to eliminate double counting. The AFW sector totals were reduced accordingly, as displayed in the Summary List above. The following overview identifies specifically where those overlaps occurred and how they were resolved.

AFW-2 addresses planting trees in urban settings. The Residential, Commercial, and Industrial (RCI) Sector also indirectly includes some tree planting to reduce energy use in buildings as part of demand-side management (DSM) and other energy efficiency programs. AFW-2 addresses urban tree canopies, existing buildings, and carbon sequestration. Only a portion of the CO_2 reductions in AFW-2 is based on energy savings from shading and protection of buildings by trees. RCI options broadly address specifically planting trees to affect energy savings in buildings across the entire state. Therefore, only 30% of the emission reductions attributable to energy savings were removed from the AFW quantifications as overlap. The related costs were then adjusted accordingly.

AFW-6 outlines how biomass may be utilized for energy production. The Energy Supply (ES) sector also quantified the use of biomass for energy production. All emission reductions and costs associated with biomass-to-energy production have been removed from AFW sector in the Sector Total After Adjusting for Overlaps row and are accounted for in ES.

AFW-7 focuses on biofuels. The availability of biomass in, and in proximity to Maryland was determined and added a constraint on the amount of energy and biofuels that could be produced. Since ethanol production is addressed in the Transportation and Land Use (TLU) sector, and since that analysis accounts for the use of available biomass for ethanol, all quantifications for AFW ethanol options have been eliminated from the total. Bio-diesel production benefits and savings in AFW were reduced to the production expected from the remaining available biomass after the TLU bio-diesel targets were met.

AFW-9 addresses reduction of waste and recycling. The raw numbers reflect the savings in all GHG emissions and costs from raw material extraction through production as well as waste stream. In the Inventory and Forecast (I&F), only the emissions produced from landfills, waste combustion, wastewater treatment and residential burning were included. Therefore, the portion of emissions and costs over and above the emissions for landfills and waste combustion were eliminated so as to more accurately reflect the difference between Business-As-Usual (BAU) trends as predicted in the Inventory and Forest and the implementation of this policy option. However, addressing waste effectively creates significant emission reductions and cost savings beyond what is now reflected in the adjusted total.

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 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.

Healthy and vigorous forests provide direct benefits to GHG reductions, as noted above, but also serve as the preferred land-use for avoiding emissions and capturing airborne GHGs. To protect those forests so they are able to meet the desired GHG objectives, it is incumbent upon the owner of those forests to attend to the necessary stewardship activities needed to keep the forests healthy and vigorous.

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, 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 GHG emissions, and sequesters more carbon. Threats from invasive species are increasing in number and severity, especially since forestlands are more vulnerable due to 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 overabundance of white-tailed deer places excessive browse pressure on regeneration and understory plants in all forests. It is difficult to quantify the effects of invasive species growth on emissions because the costs of implementation and the efficacy of management strategies can vary widely.

Sustainable forest management is the practice of managing forest resources to meet the long-term forest product needs of humans while maintaining the biodiversity of forested landscapes. The primary goal is to restore, enhance, and sustain a full range of forest values—economic, social, and ecological.

Policy Design

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

Goals Related to Forest Management:

- Improve sustainable forest management on 25,000 acres of private land by 2020.

- Improve sustainable forest management on 100% of state-owned resource lands by 2020.

Goals Related to Forest Pests and Invasive Species (not quantified):

- Develop a prioritization process for invasive species, identifying species of high priority for targeted action.
- Shift decision-making efforts to plan ahead for invasive species problems—move towards prevention or proactive management rather than control and reactive treatments.

Parties Involved: Maryland Department of Natural Resources (DNR), Maryland Department of the Environment (MDE), Maryland Department of Agriculture (MDA), Maryland Department of Transportation (MDOT), Maryland State Highway Administration (SHA), counties, Chesapeake Bay Program, Natural Resource Conservation Service (NRCS), United States Forest Service–State and Private Forestry (USFS-SPF), United States Fish and Wildlife Service (USFWS), private landowners, public landowners, private sawmills, landscaping industry, nursery industry, Maryland Cooperative Extension (MCE), master gardeners, and the artisan community.

Implementation Mechanisms

- Provide outreach and education on best forest management practices.
- Provide outreach and education about invasive species and control methods.
- Revise the Forest Conservation Management Act (FCMA) to be consistent with the recommendations contained herein.
- Use a bona fide certification system[1] with the aim of certifying all state-owned forestlands as sustainably managed.
- Support a Sustainable Forestry Act that encourages enhanced carbon storage in forests, use of durable wood products, and use of wood biomass for energy, while maintaining healthy forest ecosystems.
- Use offset funds to enhance forest management on private lands and reduce conversion to other land uses. See Related Polices/Programs in Place.
- Include sustainable forest management in the Regional Greenhouse Gas Initiative (RGGI) Model Rule.
- Develop a mechanism to aggregate products from smaller land holdings to compete in meaningful markets.
- Investigate the feasibility of legislation restricting the sale of priority non-native invasive species.

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[1] Forest certification is a system for identifying well-managed forestland. In this context, sustainability includes maintenance of ecological, economic, and social components. Products from certified forestland can, through chain-of-custody certification, move into production streams and in the end receive labeling that allows customers to know the product came from a certified, well-managed forest. Fully implemented, certification will become a market-based mechanism to reward superior forest management. The Forest Stewardship Council (FSC) is a nongovernmental, international organization that accredits third-party certifiers and facilitates development of forest management standards. Certifiers include Scientific Certification Systems (California), SmartWood (New York), and regional affiliates.

Related Policies/Programs in Place

- FCMA
- Incentive programs for private forestland owners (e.g., Woodland Incentive Program, Forest Conservation and Management Agreements, Woodland Assessment Program, and the Tax Modification for Forest Management program), which provide either cost-share funds or tax breaks for appropriate management of their forests.
- U.S. Department of Agriculture (USDA) programs for forests and related wetlands and USFWS reforestation and wetlands programs for habitat improvement.

Type(s) of GHG Reductions

CO_2 (quantified): Enhancement of annual carbon sequestration from forest growth and reforestation through forestry management programs.

CO_2 (not quantified): Remove fuels that contribute to wildfire emissions. Maintain carbon sequestration through the production of durable wood products. Reduce emissions by reducing use of fossil fuels and replace them with 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

Data Sources:

- Forest-type distribution in Maryland and landownership statistics from the USDA Forest Inventory and Analysis (FIA), available at: http://fia.fs.fed.us.
- J.E. Smith, L.S. Heath, K.E. Skog, and R.A. Birdsey. 2006. Methods for calculating forest ecosystem and harvested carbon with standards estimates for forest types of the United States. USDA United States Forest Service (USFS) Northern Research Station. General Technical Report GTR-NE-343. (Also published as part of the United States Department of Energy [US DOE] Voluntary GHG Reporting Program.) Available at http://www.treesearch.fs.fed.us/pubs/22954 (ne_gtr343.pdf)

Quantification Methods:

While experts largely agree sustainably managed forests may store substantially more carbon on an annual basis than forests not managed sustainably, few data are currently available to quantify exactly what kinds of sites can store exactly how much additional carbon, and under what silvicultural regimes. Furthermore, some existing forests are indeed being managed sustainably, such that determining the amount of acreage available for improved forest management can be difficult.

To calculate the effect of improved forest management on carbon sequestration in Maryland, the additional carbon stored as a result was indexed using data on rates of carbon storage in average loblolly-shortleaf pine stands compared with carbon storage rates in high-productivity, intensively managed loblolly-shortleaf pine stands in the Southeast (GTR-NE-343, Tables A39 and A40). The index of incremental carbon storage was calculated over a 90-year period to capture slowdown in forest carbon sequestration that typically occurs in maturing forest stands.

Soil carbon was assumed to remain constant with time, because there is no change in estimates of soil carbon pools over time in the General Guidelines for the Voluntary Reporting of Greenhouse Gases Program (under Section 1605(b) of the Energy Policy Act of 1992). The incremental rate of carbon storage, due to intensive management in loblolly-shortleaf pine stands relative to average loblolly-shortleaf pine stands in the Southeast, is roughly 5% (Table I-1).

Table I-1. Carbon sequestration rates under average and intensive management scenarios for loblolly-shortleaf pine forests in the Southeast United States following clear-cut harvest

Forest Type	tC/acre (0 year)	tC/acre (90 year)	tC/acre/year	Increment in tC/acre/year Due to Management
Loblolly-shortleaf pine stands (GTR-NE-343, Table A39)	10.7	60.5	0.553	
Loblolly-shortleaf pine on high productivity sites under intensive management (GTR-NE-343, Table A40)	14.9	67.0	0.579	5%

tC/acre = metric tons of carbon per acre.

Forests in Maryland are 63% oak-hickory, with 10% oak-pine and 11% loblolly-shortleaf pine.[2] The remaining 16% of forestland area is a mixture of forest types. Coefficients for improved productivity in oak-hickory and oak-pine stands were not available. The rate of carbon sequestration, due to improved forest management in these forest types, was thus calculated as a proportion of average carbon sequestration in forests under typical management, using the 5% value calculated for incremental carbon storage in loblolly-shortleaf pine stands (Table I-2).

Table I-2. Estimated carbon sequestration rates on forestland under intensive management

Forest Type	tC/acre (0 year)	tC/acre (65 year)	tC/acre/year	tC/acre/year Under Intensive Management
Oak-hickory (GTR NE 343, Table A3)	23.0	72.7	0.765	0.800
Oak-pine (GTR NE 343, Table A4)	25.9	63.4	0.577	0.604
Loblolly-shortleaf pine (GTR NE343, Table A39)	10.7	51.8	0.632	0.662

tC/acre = metric tons of carbon per acre.

Forest carbon sequestration rates under baseline conditions (no improved forest management) were based on published carbon stocks (tons of carbon per acre [tC/acre] in forest biomass) for oak-hickory and oak-pine in the Northeast and for loblolly-shortleaf pine stands in the Southeast (USFS GTR-NE-343). Annual rates of carbon sequestration (tC/acre/year) were calculated by subtracting total carbon stocks in forest biomass of 65-year-old stands from total carbon stocks in

[2] USDA USFS Northern Global Change Program, Available at http://www.fs.fed.us/ne/global/pubs/books/epa/states/MD.htm

forest biomass of new stands and dividing by 65. An average for 65-year-old stands was used to reflect the typical stand age of forests in the Northeast region.

Quantification for this option was based on a combined goal of achieving enhanced forest management on 25,000 acres of private land and 100% of state-owned forestland by 2020. Based on 2004 FIA data, state-owned forests total 749,975 acres[3] in Maryland, roughly 31.2% of the 2.4 million forested acres statewide. Other forestland ownership entities in the state include the USFWS (42,561 acres), county and municipal government (41,148 acres) and privately owned forests (1,567,846 acres). This acreage includes all land classified as forest by FIA and owned by the State of Maryland, regardless of which branch of state government is currently responsible for managing that forest.

A linear ramp-up in implementation is assumed. Thus, each year from 2008 to 2020, the analysis assumes 1,923 acres of private land and 57,690 acres of public land are added to the land base practicing sustainable forest management. Therefore, the effect of policy implementation is the incremental carbon stored on these lands is over and above expectations if enhanced forest management were not implemented. Baseline and policy implementation scenarios assume the distribution of forests affected by the program will reflect the distribution of forests statewide: 70% oak-hickory, 15% oak-pine, and 15% loblolly-shortleaf pine. Acreage enrolled in the program in one year is assumed to continue sequestering additional carbon in subsequent years. Table I-3 summarizes the total carbon storage resulting from enhanced forest management.

[3] USDA USFS FIA EVALIDator version 1.0. Available at http://fiatools.fs.fed.us/

Table I-3. Additional acreage and carbon sequestration resulting from expanded land base participating in sustainable forest management

Year	Private Land Added to Sustainable Forest Management This Year	Added in Prior Years	Public Land Added This Year	Public Land Added in Prior Years	Additional Carbon Storage ($MMtCO_2e$/year)
2008	1,923	0	57,690	0	0.007
2009	1,923	1,923	57,690	57,690	0.014
2010	1,923	3,846	57,690	115,381	0.022
2011	1,923	5,769	57,690	173,071	0.029
2012	1,923	7,692	57,690	230,762	0.036
2013	1,923	9,615	57,690	288,452	0.043
2014	1,923	11,538	57,690	346,142	0.051
2015	1,923	13,462	5,7690	403,833	0.058
2016	1,923	15,385	57,690	461,523	0.065
2017	1,923	17,308	57,690	519,213	0.072
2018	1,923	19,231	57,690	576,904	0.080
2019	1,923	21,154	57,690	634,594	0.087
2020	1,923	23,077	57,690	692,285	0.094
Total	**25,000**		**749,975**		**0.658**

$MMtCO_2e$ = million metric tons of carbon dioxide equivalent.

The economic cost of implementing enhanced forest management on forest acreage is a one-time cost (over and above the cost to implement standard management techniques) of improved forest management practices and is estimated to be $151.50/acre. This value is an average of values from other states where similar policy options have been quantified: Vermont, where a value of $3/acre was used,[4] and Montana, where a value of $300/acre was used.[5] Clearly, there is little consensus about what is required to implement an enhanced forest management program and, as a result, the estimates of how much it will cost to implement these policies varies widely. State-specific data would substantially improve the validity of the estimate of economic costs for this option in Maryland. At $151.50/acre, and using a discount rate of 5%, the net present value (NPV) of this option is $89.1 million (Table I-4), with an overall cost-effectiveness of $135.31 per metric ton of carbon dioxide equivalent (tCO_2e) stored.

[4] http://www.vtclimatechange.us

[5] http://www.mtclimatechange.us

Table I-4. Total economic costs for implementing improved forest management on combined private and public acreage in Maryland

Year	Carbon Sequestered ($MMtCO_2e$/year)	Total Cost	Discounted Cost
2008	0.007	$9,031,439	$9,031,439
2009	0.014	$9,031,439	$8,601,371
2010	0.022	$9,031,439	$8,191,782
2011	0.029	$9,031,439	$7,801,697
2012	0.036	$9,031,439	$7,430,188
2013	0.043	$9,031,439	$7,076,369
2014	0.051	$9,031,439	$6,739,399
2015	0.058	$9,031,439	$6,418,475
2016	0.065	$9,031,439	$6,112,834
2017	0.072	$9,031,439	$5,821,746
2018	0.080	$9,031,439	$5,544,520
2019	0.087	$9,031,439	$5,280,496
2020	0.094	$9,031,439	$5,029,043
Total	**0.658**	**$117,408,713**	**$89,079,360**

$MMtCO_2e$ = million metric tons of carbon dioxide equivalent.

Key Assumptions:

- Carbon storage resulting from sustainable management of oak-hickory and oak-pine types is indexed to incremental carbon storage in loblolly-shortleaf-pine forests, as quantified using methods in GTR-NE-343.
- One-time costs to implement enhanced forest management are $151.50/acre, and include costs over and above standard costs for forest management operations.
- Forest types added to the pool of sustainably managed forests will reflect the distribution of forests statewide.

Key Uncertainties

GHG emissions from management activities, such as harvest, are not included in this analysis. To provide clarity about the effects of policy implementation, it is important to quantify the changes in emissions resulting from changes in management practices due to policy implementation.

Additional Benefits and Costs

As markets are developed, additional biomass generated via enhanced forest management will be used first for long-term storage in durable wood products and then for beneficial uses, such as biofuels and energy. The biomass generated from improved management practices could be used for durable wood products and energy production. The quantification described above assumes additional carbon is stored in the forest.

Forest certification will likely be necessary for participation in the RGGI market, but effects of certification are not quantified here because effects on carbon storage are uncertain and because the costs are difficult to quantify.

Feasibility Issues

Sustainable forest management is well researched, and offers a plethora of mandated and voluntary BMPs. The primary hurdle remains one of education and incentives that will move existing marginal practices or inaction to engaged, sustainable management.

Status of Group Approval

Approved.

Level of Group Support

Unanimous.

Barriers to Consensus

None.

AFW-2. Managing Urban Trees and Forests for Greenhouse Gas (GHG) Benefits

Policy Description

Healthy, sustainable urban forests are essential to our social, economic, and environmental welfare. This policy option maintains and improves the health and longevity of trees in urban and residential areas. Trees in urban areas help avoid emissions from power production, and from the operation and maintenance (O&M) of built structures and infrastructure. Further, urban trees contribute to lower summertime temperatures at street level. Reduced heat slows the formation of ground-level O_3, as well as the evaporation and volatilization of organic compounds from vehicles. Trees also take in CO_2 for photosynthesis, storing carbon in their biomass through growth. Trees likewise reduce ambient concentrations of volatile organic compounds, nitrous oxide (N_2O), fine particulate matter, and other air and water pollutants.

Statewide, the urban canopy cover in Maryland is 40.1%.[6] This option seeks to increase the canopy cover of urban trees throughout the state. Planting additional trees in-state may: increase the utilization of wood recovered from urban trees for energy production or in value-added products for long-term carbon storage; encourage species diversity while extending survival and longevity rates through the creation of amenable microclimates; and address insects, invasive species, and disease in urban forest settings, though these impacts are not quantified here.

Policy Design

Educate the public and legislators on the importance of urban forests for O_3 and temperature regulation, leading to reduced energy use.

Goals:

- Enhance green infrastructure planning including tying green areas together (not quantified).
- Develop incentives to better use urban wood recovery directed toward the highest-order wood product (not quantified), with the remainder recovered for biomass to energy conversion (see AFW-6).
- Achieve urban tree canopy (UTC) goal of 50% (averaged over all urban land-use types) by 2020.

Goals Related to Forest Pests and Invasive Species (Not Quantified):

- Develop prioritization process for invasive species, identifying species of high priority for targeted action.
- Shift decision-making efforts to plan ahead for invasive species problems—move towards prevention or proactive management, rather than control and reactive treatments.

Timing: See quantified goal above.

[6] USDA USFS data (D. Nowak). Available at http://www.fs.fed.us/ne/syracuse/Data/State/data_MD.htm.

Parties Involved: DNR, MDE, MDA, MDOT, SHA, counties, municipalities, Chesapeake Bay Program, NRCS, USFS Urban and Community Forestry, private landowners, public landowners, private sawmills, artisan community, landscaping industry, nursery industry, arborist industry, MCE, and master gardeners.

Implementation Mechanisms

- Encourage the funding and expansion of planting programs in all communities, including a replacement program for dead trees, where a tree with equal potential is planted in a site as good as or better than the original to maximize longevity and efficacy.
- Insert urban tree planting strategy and objectives in all comprehensive plans.
- Encourage local counties to identify, maintain, and augment street tree populations.
- Provide outreach and education on the significance of trees and their role in our built environment.
- Monitor and report plantings at the local level.
- Provide enhanced funding from conservation programs like Program Open Space (POS) to local jurisdictions to implement policies (e.g., wood recovery and canopy goals) and to plant trees.
- Implement legislation restricting sale of priority non-native invasive species.
- Outreach and education about invasive species and control methods.
- To strengthen, fund, and support this act, add UTC goals to the Urban Community Forest Act.

Related Policies/Programs in Place

Urban Community Forestry Act.

Tree-mendous Maryland, a program that, for a fee, individuals can request a tree be planted as a memorial.

Chesapeake Bay Program's Forest Conservation Directive 2020 goals. The Governor of Maryland committed to establishing urban canopy goals by 2020 for 50% of the area developed before storm-water management regulations (i.e., pre-1984), among other goals.

Community Woodlands Alliance, a group of local artisans building furniture from old-growth urban trees.

Type(s) of GHG Reductions

CO_2 (quantified): Avoidance of emissions of CO_2 and associated GHGs through the reduction of heating and cooling needs in urban areas. Carbon sequestration due to tree growth.

CO_2 (not quantified): Decrease in surface temperatures reducing volatilization of gases from vehicles. Maintaining carbon sequestration by creating durable wood products. Reduce use of fossil fuels by using wood waste for energy.

The emissions saved as calculated under this policy option overlap with some options recommended in the RCI Technical Work Group (TWG). These AFW policy emissions are related only to trees in urban settings, whereas the energy-savings emission reductions are calculated across the state under RCI. Therefore, the emission reductions that result from energy savings for this policy option have been reduced by 30% (see Sector Total after Adjusting for Overlap on Summary List.)

Estimated GHG Reductions and Net Costs or Cost Savings

Data Sources:

- Data about existing and potential UTC cover for Maryland from:
  - M.F. Galvin, J.M. Grove, and J. O'Neill-Dunne. 2006a (Jan.). A report on Baltimore City's present and potential urban tree canopy. Prepared for The Honorable Mayor Martin O'Malley, City of Baltimore. Available at http://www.dnr.state.md.us
  - M.F. Galvin, J.M. Grove, and J. O'Neill-Dunne. 2006b (June). A report on Annapolis' present and potential urban tree canopy. Prepared for The Honorable Mayor Ellen O. Moyer, City of Annapolis. Available at http://www.dnr.state.md.us
  - M.F. Galvin, J. O'Neill-Dunne, and J.M. Grove. 2008. A report on the City of Frederick's existing and possible urban tree canopy. Available at http://www.dnr.state.md.us
- Information about current numbers of trees in urban forest and annual carbon storage in urban trees in Maryland: USDA USFS Northern Research Station. Urban forest effects on environmental quality state summary data for Maryland (2003). Available at http://www.fs.fed.us/ne/syracuse/Data/State/data_MD.htm
- Parameters for energy and emission savings of tree planting: E.G. McPherson and J.R. Simpson. 1999. CO_2 reduction through urban forestry: guidelines for professional and volunteer tree planters. USDA USFS Pacific Southwest Research Station. General Technical Report PSW-GTR-171.
- Data on costs and benefits of tree planting: E.G. McPherson et al. 2006. Piedmont community tree guide: benefits, costs, and strategic planting. USDA USFS Pacific Southwest Research Station. General Technical Report PSW-GTR-200.
- Additional data on benefits of tree canopy in Maryland: M.F. Galvin. 2007. A report on Hyattsville's street trees. Prepared for The Honorable William F. Gardiner, Mayor and James Chandler, Community Development Manager. Available at http://www.dnr.state.md.us

Quantification Methods:

The following quantifies the cumulative impact on carbon sequestration and avoided fossil fuel emissions of incrementally increasing the existing tree canopy cover in Maryland. Specifically, AFW-2 seeks to achieve a goal of 50% urban canopy cover by 2020. Currently, Maryland's urban areas are 40.1% forested.[7] This goal recommends a 25% increase over the existing canopy cover by 2020. The goal of 50% is based on recent assessments of existing and potential UTC in Maryland. For example, Baltimore currently has a canopy cover of 20%, and a goal of 46.3% is

[7] USDA USFS data (D. Nowak). Available at http://www.fs.fed.us/ne/syracuse/Data/State/data_MD.htm.

recommended as feasible within the 2030–2036 time frame (Galvin et al. 2006a). Annapolis' urban areas are currently 41% forested, and a 50% goal is recommended within the same time frame (Galvin et al. 2006b). Frederick is currently only 12% forested (Galvin et al. 2008), but there appear to be no obvious barriers to increasing its UTC. While the UTC analyses cited above recommend a longer time frame to reach the UTC targets, this analysis seeks to quantify the effects of policy implementation within the 2008–2020 time frame described by the Mitigation Working Group (MWG).

Currently, Maryland contains 89.4 million urban trees; this option quantifies the effect of adding a total of 22 million new trees by 2020. The number of trees planted each year is constant at roughly 1.7 million/year, with the target number of trees planted by 2020.

GHG benefits are twofold: direct carbon sequestration by planted trees, and avoided GHG emissions from strategic tree planting to reduce energy demand due to heating and cooling.

A. Direct Carbon Sequestration in Urban Trees

Annual carbon sequestration per urban tree is calculated as 0.006 metric tons of carbon dioxide equivalents per tree per year (tCO_2/tree/year), based on statewide average data reported by the USFS. This is the average annual per-tree carbon sequestration value when the total estimated urban forest carbon accumulation in Maryland (544,000 tCO_2/year) is divided by the total number of urban trees in Maryland (89.4 million). Since trees planted in one year continue to accumulate carbon in subsequent years, annual carbon sequestration in any given year is calculated as the sum of carbon stored in trees planted in that year, plus the sequestration by trees planted in prior years. Because it simply takes the difference between total live C stocks at two points in time, this stock change approach accounts for normal tree mortality.

B. Avoided Fossil Fuel Emissions

Offsets from avoided fossil fuel use for heating and cooling are the sum of three different types of savings: (1) avoided emissions from reduced cooling demand, (2) avoided emissions from reduced demand for heating due to wind reduction (this benefit is only available for evergreen trees), and (3) enhanced fossil fuel emissions needed for heat due to wintertime shading. Calculations for avoided fossil fuel offsets are based on calculations presented by McPherson et al. (1999) (see Table I-5). For this analysis, it was assumed half of the trees would be planted in residential settings or close enough to buildings to result in avoided emissions. Where plantings are assumed to provide this avoided emissions benefit, it was further assumed the trees planted would be evenly split among residential settings with pre-1950, 1950–1980, and post-1980 homes and all planted are medium-sized evergreens. These avoided emission factors assume average tree distribution around buildings (i.e., these fossil fuel reduction factors are average for existing buildings, but do not necessarily assume trees are optimally placed around buildings to maximize energy efficiency). These factors are also dependent on the fuel mix (e.g., coal, hydroelectric, or nuclear) in the region, and thus are likely to change if the electricity mix changes from its 1999 distribution.

Table I-5. Factors used to calculate CO2e savings (MMtCO2e/tree/year) from reduced need for fossil fuel for heating and cooling and from windbreak effect of evergreen trees

Fossil Fuel Offsets: Evergreen Trees (Mid-Atlantic Climate Region)			Wind–Heating	Net Effect
Housing Vintage	**Shade–Cooling**	**Shade–Heating**		
Pre-1950	0.0168	–0.0315	0.1294	0.1147
1950–1980	0.0275	–0.0403	0.1555	0.1427
Post-1980	0.0232	–0.0324	0.133	0.1238
Average	0.0225	–0.0347	0.1393	0.1271
Average (MMtCO$_2$e)				1.2707

MMtCO$_2$e = million metric tons of carbon dioxide equivalent.

Source: McPherson et al., 1999

C. Overall GHG Benefit of Urban Tree Planting

Total GHG benefits are calculated as the sum of direct carbon sequestration plus fossil fuel offset from reduced cooling demand and wind reduction (Table I-6).

Table I-6. Overall GHG benefit (MMtCO2e/year) of implementing AFW-2

Year	Trees Planted This Year	Trees Planted in Previous Years	GHG Sequestered (MMtCO$_2$e/year)	GHG Avoided (MMtCO$_2$e/year)	Overall GHG Savings (MMtCO$_2$e/year)
2008	1,698,440	0	0.0379	0.1079	0.1458
2009	1,698,440	1,698,440	0.0758	0.2158	0.2916
2010	1,698,440	3,396,879	0.1136	0.3237	0.4374
2011	1,698,440	5,095,319	0.1515	0.4316	0.5832
2012	1,698,440	6,793,759	0.1894	0.5395	0.7289
2013	1,698,440	8,492,198	0.2273	0.6474	0.8747
2014	1,698,440	10,190,638	0.2652	0.7554	1.0205
2015	1,698,440	11,889,078	0.3030	0.8633	1.1663
2016	1,698,440	13,587,517	0.3409	0.9712	1.3121
2017	1,698,440	15,285,957	0.3788	1.0791	1.4579
2018	1,698,440	16,984,397	0.4167	1.1870	1.6037
2019	1,698,440	18,682,836	0.4546	1.2949	1.7495
2020	1,698,440	20,381,276	0.4924	1.4028	1.8952
Total		**22,079,716**	**3.4471**	**9.8196**	**13.2667**

GHG = greenhouse gas; MMtCO$_2$e/year = million metric tons of carbon dioxide equivalent per year.

D. Cost Analysis

Economic costs of tree planting are calculated as the sum of tree planting and annual maintenance, including the costs of program administration and waste disposal. Economic benefits of tree planting include the cost offset from reduced energy use, as well as the estimated economic benefits of services (e.g., provision of clean air), hydrologic benefits (e.g., storm water control), and aesthetic enhancement.

The cost of tree planting in Maryland was assumed to be $275/tree.[8] This is a one-time cost incurred in the year of planting. Annual maintenance costs include pruning, pest management, administration, removal, and infrastructure repair due to damage from trees. Over a 40-year period, these costs were estimated at $22/tree/year, based on McPherson et al. (2006). This value assumes a medium-sized evergreen tree and is an average of trees under public and private management. This value is consistent with annualized maintenance costs per tree published for other states and regions. It was assumed trees planted in the first year of policy implementation would still be living at the end of the policy implementation period; in other words, the effects of tree mortality are not explicitly accounted for in the analysis of the numbers of trees planted to achieve the canopy goals described above.

The economic benefit of planting urban trees includes the value of aesthetic improvement, air and water quality improvements, stormwater management, and energy savings. Annual economic benefit per tree was estimated at –$96.30/tree/year, using information from Galvin et al. (2007) on the economic value of Hyattsville, Maryland's urban forest. Consistent with convention, the economic benefit per tree planted is a negative number since the economic benefit outweighs the cost of the option. When the economic benefit of an option outweighs its cost, then the resulting net economic cost is negative.

Net economic costs for this option are calculated as the difference between costs of planting and maintenance and economic benefit realized by urban trees. Therefore, negative costs refer to net economic benefits, where estimated benefits exceed overall costs. For this analysis, net economic benefit per tree was estimated at –$74.30/tree/year. Discounted costs were calculated assuming a 5% discount rate (Table I-7). AFW-2 has a net economic benefit of –$152.00/t$CO_2$e mitigated.

[8] Mike Galvin, Supervisor, Urban and Community Forestry, Maryland DNR. Personal communication with J. Jenkins, January 2008. Range of costs estimated at $250-300.

Table I-7. Economic benefits and costs of implementing AFW-2

Year	Trees Planted This Year	Trees Planted in Previous Years	Total Economic Benefit	Net Benefit (Costs Minus Benefits)	Discounted Net Benefits
2008	1,698,440	0	$0	$467,070,909	$467,070,909
2009	1,698,440	1,698,440	$163,559,740	$340,876,842	$324,644,611
2010	1,698,440	3,396,879	$327,119,480	$214,682,774	$194,723,605
2011	1,698,440	5,095,319	$490,679,221	$88,488,707	$76,439,872
2012	1,698,440	6,793,759	$654,238,961	–$37,705,361	–$31,020,294
2013	1,698,440	8,492,198	$817,798,701	–$163,899,428	–$128,419,491
2014	1,698,440	10,190,638	$981,358,441	–$290,093,496	–$216,472,233
2015	1,698,440	11,889,078	$1,144,918,182	–$416,287,563	–$295,847,799
2016	1,698,440	13,587,517	$1,308,477,922	–$542,481,631	–$367,172,921
2017	1,698,440	15,285,957	$1,472,037,662	–$668,675,698	–$431,034,317
2018	1,698,440	16,984,397	$1,635,597,402	–$794,869,766	–$487,981,084
2019	1,698,440	18,682,836	$1,799,157,142	–$921,063,833	–$538,526,947
2020	1,698,440	20,381,276	$1,962,716,883	–$1,047,257,901	–$583,152,386
Total		**22,079,716**	**$12,757,659,738**	**–$3,771,215,443**	**–$2,016,748,473**

Key Assumptions: Economic costs and benefits of urban tree cover. Feasibility of accelerated implementation of UTC recommendations. Each community has the capacity and technical skill to assess the appropriate species and location for trees planted.

Key Uncertainties

Cities and communities would need to conduct canopy surveys to establish a baseline of current canopy cover. The costs of such a survey and continued monitoring are variable and may exceed available resources. The longevity of urban trees may be affected by climate perturbations.

Additional Benefits and Costs

In addition to the numerous benefits articulated in the policy description, urban trees contribute to improved property values, add aesthetic value for residents and visitors, provide humidity balancing, and reduce the intensity of stormwater runoff. Sociological studies suggest that more attractive and comfortable neighborhoods have lower crime rates.

Feasibility Issues

Ensuring a constant source of quality urban trees for achieving planting goals without incurring excessive transportation costs is of concern.

Finding the necessary funding in a constant flow per annum is another concern.

Status of Group Approval

Approved.

Level of Group Support

Unanimous.

Barriers to Consensus

None.

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

Policy Description

Increasing forest and tree cover provides additional benefits for mitigation of GHGs in addition to sequestration. 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 long as 20 years. Forest patches should be sufficient in size to function as a community of trees and related species.

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, 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 on those disturbed lands.

Policy Design

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

Maryland is a member of the RGGI (http://www.rggi.org), which mandates the existence of an interstate CO_2 Budget Trading Program to reduce emissions from the power sector (RGGI applies to fossil fuel-burning plants larger than 25 megawatts [MW]). Beginning with implementation of the CO_2 Budget Trading Program on January 1, 2009, emissions entities are permitted to use offset projects to meet up to 3.3% of their emission limitations (this could increase to 5% and 10% in later years). Specific uses of revenues from the sale of carbon credits are 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, to be eligible for RGGI as currently written, a forest-offset project must

- Be an afforestation project (i.e., land must have been in a non-forested condition for at least 10 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 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), Institute for Sustainable Forestry (ISF), American Tree Farm System® (ATFS), or 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 CO_2 Budget Trading Program in the future.

While the above requirements are prerequisites for participation in the RGGI offset program, all categories of afforestation and reforestation projects will reduce the atmospheric GHG burden. In addition, all categories of easements (in perpetuity or long-term) will have GHG benefits. Thus, AFW-3 is not limited to projects eligible for RGGI participation, and the associated costs of easement purchase and certification have been excluded from the quantification.

Wetlands and marshlands protection has been cited as one of the best ways to save lives and prevent property damage in coastal areas. To ensure that wetland buffers will be available for Maryland, current wetlands need to be able to move inland as sea level rises. Without inland areas to which these wetlands can migrate, the Chesapeake Bay's coastal wetlands could simply be drowned by rising Bay waters. Acquisition of lands adjacent to existing tidal marsh in fee simple or by conservation easements is essential for wetlands to migrate landward as sea level rises.

Wetlands with long periods of inundation or surface saturation during the growing season are especially effective at storing carbon in the form of peat, though there are uncertainties associated with carbon storage in wetlands (see Key Uncertainties below). Salt marsh and forested wetlands tend to release less methane (CH_4) than freshwater marsh. Riparian wetlands can also capture carbon washed downstream in litter, branches, and sediment. Because they accumulate sediment and bury organic matter, floodplain and tidal wetlands are especially effective as carbon sinks. These lands also reduce nutrient, sediment, and other pollution into the Chesapeake Bay and other bodies of water.

Goals:

- Establish sufficient acreage in forests to offset the loss of 900 acres each month to development, beginning in June 2008 and continuing through December 2020.
- Establish riparian buffers at a rate of 360 miles/year (50-foot width either side of stream) to 2020 and continue until 70% of all stream miles in the state are buffered. (This goal assumes that 40% of the 900-mile/year goal described in Chesapeake Bay Forest Conservation Initiative of December 2007 will be met with riparian forest establishment in Maryland.)
- Increase wetland areas where ever feasible (nonquantified goal).

Timing: See goals, above.

Parties Involved: DNR, SHA, MDA, MDE, Chesapeake Bay Program, NRCS, counties, private landowners, U.S. Army Corps of Engineers (USACE), Port Authority, USFWS, nonprofit conservation organizations, Baltimore (and other cities) reservoir watershed management.

Implementation Mechanisms

- Outreach and education.
- Green infrastructure plans.
- FCMA.
- Maryland Tidal Wetlands Act, and non-tidal wetlands regulatory programs and associated no-net loss of wetlands goals.
- MDE–Shoreline Erosion Control Guidelines: Marsh Creation. Available at http://www.mde.state.md.us/assets/document/wetlandswaterways/Shoreerosion.pdf
- MDE–Water Quality Infrastructure Program, which manages federal and state grants, some of which are directed at small creeks and estuaries restoration. Available at http://www.mde.state.md.us/Programs/WaterPrograms/WQIP/wqip_smallcreeks.asp
- MDE–Wetlands and Waterways Program (with targeting documents for prioritizing wetlands for restoration, preservation, and mitigation: one for all of Maryland and one for Maryland's Coastal Bays' watersheds). Available at http://www.mde.state.md.us/Programs/WaterPrograms/Wetlands_Waterways/about_wetlands/prioritizingareas.asp
- FCMA provides landowners with a reduction in property taxes on lands actively managed for forest conservation, including newly planted areas.
- Other property and inheritance tax incentives.
- Economic incentive to private landowners, including promotion of nontraditional products (e.g., hunting leases), and quiet recreation (e.g., photography, hiking, bird watching).
- Review fee-in-lieu dollars (amount and use) within the FCMA. 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 restore or conserve an equal amount of forests as is lost to that development.
- Allowances from RGGI auctions should be available for reforestation and restoration.
- Recommendation that the Maryland Commission for Climate Change (MCCC) and RGGI increase acknowledgment and importance of forests as significant in climate change mitigation.
- Utility companies are not currently required to offset acres of forest lost to corridor development. A bill was introduced into the 2008 legislature to address this issue (SB 654), but no action was taken before the legislature adjourned. Reintroduction of this bill is encouraged.

Related Policies/Programs in Place

FCMA: See example from Washington County in implementation of the FCMA (Forest Conservation Ordinance, adopted in 1993).[9]

[9] http://www.washco-md.net/washco_2/pdf_files/legal/forestcn.pdf

Chesapeake Bay Commission 2020 goals for Maryland that the Governor committed to include restoring an additional 25,000 acres of forest buffers or other areas of high value to water quality outside of prime agricultural land by 2020.

The MDOT, under offset requirements, must reforest an amount of acreage equal to that developed for major highways.

Municipal Reservoir Watershed Management Plans. (For example, Maryland Department of Public Works [DPW] Bureau of Water and Wastewater, which operates three reservoir watersheds: Loch Raven Reservoir, Liberty Reservoir, and Pretty Boy Reservoir for the City of Baltimore.)

Type(s) of GHG Reductions

CO_2: Increasing annual carbon sequestration from establishing forest and riparian cover.

Estimated GHG Reductions and Net Costs or Cost Savings

Data Sources:

J.E. Smith, L.S. Heath, K.E. Skog, and R.A. Birdsey. 2006. Methods for calculating forest ecosystem and harvested carbon with standard estimates for forest types of the United States. USDA USFS Northeastern Research Station. General Technical Report GTR-NE-343. (This document is also published as part of the US DOE 1605(b) Voluntary GHG Reporting Program).

USDA USFS FIA data, provided by the USFS for the Maryland Forestry I&F.[10]

S. Walker, S. Grimland, J. Winsten, and S. Brown. 2007. Terrestrial carbon sequestration in the Northeast: opportunities and costs part 3A: opportunities for improving carbon storage through afforestation of agricultural lands. Report to The Nature Conservancy Conservation Partnership Agreement by Winrock International, prepared with the support of the US DOE under Award No. DE-FC26-01NT41151.

Quantification Methods:

A. Afforestation

1. 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, carbon sequestered by afforestation activities was assumed to occur at the same rate as carbon sequestration in average Maryland forests. Average carbon storage was determined based on USFS GTR-NE-343, assuming afforestation activity with a forest type distribution of 70% oak-hickory, 15% oak-pine, and 15% loblolly-shortleaf pine. This distribution is reflective of the average forest composition in Maryland and is based on USFS FIA statistics. A 45-year project period was assumed, such that the rate of forest carbon sequestration under afforestation projects for an average acre in Maryland was estimated at 1.2 tC/acre/year. (Table I-8). Forests planted in

[10] Data set obtained from Maryland FIA data and provided to CCS for the Maryland I&F by Dr. J.E. Smith, USDA USFS.

one year continue to sequester carbon in subsequent years. Thus, carbon storage in a given year is calculated as the sum of annual carbon sequestration on cumulative planted acreage.

Table I-8. Forest carbon sequestration rates for afforestation activity

Forest Type	tC/acre (0 year)	tC/acre (45 year)	tC/acre/year
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**

tC/acre = metric tons of carbon per acre.

The rate of afforestation was estimated at 900 acres/month, for a total of 10,800 acres afforested annually. In 2008, it was assumed 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 million metric tons of carbon dioxide equivalent ($MMtCO_2e$) stored (Table I-9).

Table I-9. Acreage planted each year under AFW-3 and total carbon sequestered

Year	Acres Planted This Year	Acres Planted in Prior Years	Carbon Sequestered (tC/year)	Carbon Sequestered ($MMtCO_2e$/year)
2008	6,300	0	7,256	0.027
2009	10,800	6,300	19,695	0.072
2010	10,800	17,100	32,135	0.118
2011	10,800	27,900	44,574	0.163
2012	10,800	38,700	57,013	0.209
2013	10,800	49,500	69,452	0.255
2014	10,800	60,300	81,891	0.300
2015	10,800	71,100	94,331	0.346
2016	10,800	81,900	106,770	0.391
2017	10,800	92,700	119,209	0.437
2018	10,800	103,500	131,648	0.483
2019	10,800	114,300	144,087	0.528
2020	10,800	125,100	156,527	0.574
Total		**135,900**		**3.903**

tC/year = metric tons of carbon per year; $MMtCO_2e$ = million metric tons of carbon dioxide equivalent.

2. 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 USFS, universities, and forest companies, and reported the 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 Table I-8 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 Maryland was estimated at $1,105. This is a one-time cost incurred in the year of planting. Based on this information, the NPV for this option is $112.7 million, with a levelized cost-effectiveness of $28.88/t$CO_2$e (Table I-10). This analysis ignores the likely economic benefits of afforestation, in terms of services such as clean air and clean water, reduced flooding, aesthetic effects, and other benefits. These benefits are typically more difficult to quantify than the tangible costs of tree planting, but they should be considered in the analysis of economic costs and benefits of afforestation activity.

Table I-10. Economic costs of afforestation

Year	Acres Planted	Total Cost	Discounted Cost
2008	6,300	$6,961,500	$6,961,500
2009	10,800	$11,934,000	$11,365,714
2010	10,800	$11,934,000	$10,824,490
2011	10,800	$11,934,000	$10,309,038
2012	10,800	$11,934,000	$9,818,131
2013	10,800	$11,934,000	$9,350,601
2014	10,800	$11,934,000	$8,905,335
2015	10,800	$11,934,000	$8,481,271
2016	10,800	$11,934,000	$8,077,401
2017	10,800	$11,934,000	$7,692,763
2018	10,800	$11,934,000	$7,326,441
2019	10,800	$11,934,000	$6,977,563
2020	10,800	$11,934,000	$6,645,298
Total	**135,900**		**$112,735,545**

B. Riparian forest

1. GHG benefit

The annual rate of riparian forest establishment was calculated from the goals established by the Chesapeake Bay Forest Conservation Initiative (2007),[11] which describe a goal of establishing 900 miles/year of 50-foot-wide buffers by 2020, continuing until 70% of all stream miles are buffered. It was assumed that 40% of these stream miles (360 miles/year would be buffered in the state of Maryland. This goal corresponds to establishing 2,182 acres/year of riparian forest by 2020. A linear ramp-up toward the goal was assumed (Table I-11).

The most common species in riparian buffers statewide are loblolly pine (21% of total stocking), green ash (10%) and sweet gum (8%). Other species in smaller proportions make up the remainder of the trees found in riparian buffers.[12] Thus it was assumed statewide that riparian

[11] http://www.chesapeakebay.net/press_ec2007forests.aspx

[12] Riparian Forest Buffer Survival and Success in Maryland, April 2001. Maryland DNR Forest Service Research Report DNR/FS-01-01. Available at http://dnrweb.dnr.state.md.us/download/forests/rfb_survival.pdf

forests would be 50% elm-ash-cottonwood and 50% loblolly-pine forest types (Table I-12). A 45-year project period was assumed, such that the rate of forest carbon sequestration in riparian projects for an average acre in Maryland was estimated at 0.9 tC/acre/year. Forests planted in one year continue to sequester carbon in subsequent years. Therefore, carbon storage in a given year is calculated as the sum of annual carbon sequestration on cumulative planted acreage (Table I-11).

Table I-11. Acres planted and carbon stored in riparian forests in Maryland

Year	Acres Planted This Year	Acres Planted in Prior Years	C Sequestered ($MMtCO_2e$/Year)
2008	168	0	0.001
2009	336	168	0.002
2010	503	503	0.003
2011	671	1,007	0.005
2012	839	1,678	0.008
2013	1,007	2,517	0.012
2014	1,175	3,524	0.015
2015	1,343	4,699	0.020
2016	1,510	6,042	0.025
2017	1,678	7,552	0.030
2018	1,846	9,231	0.036
2019	2,014	11,077	0.043
2020	2,182	13,091	0.050
Cumulative totals	**15,273**		**0.250**

C = carbon; $MMtCO_2e$ = million metric tons of carbon dioxide equivalent.

Table I-12. Forest carbon sequestration rates for riparian forest establishment

	tC/acre (0 year)	tC/acre (45 year)	tC/acre/year
Loblolly pine (Southeast) (NE-GTR Table B39)	1.7	41.9	0.9
Elm-ash-cottonwood (South Central) (NE-GTR Table B46)	1.7	41.8	0.9

tC/acre = metric tons of carbon per acre.

2. Economic Costs

Estimated per acre costs for establishment of riparian forest in Maryland were assumed to be the same as for afforestation and were obtained from Walker et al. 2007. 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. Since riparian forests were assumed to be softwoods and hardwoods in equal proportions, the weighted average cost to plant an acre of forest in Maryland was estimated at $1,055. This is a one-time cost incurred in the year of planting. Based on this information, the

NPV for this option is $11.0 million, with a levelized cost-effectiveness of $44.19/tCO_2e$ (Table I-13). As with the afforestation option above, this analysis ignores the likely economic benefits of riparian forest establishment in terms of services, such as clean air and clean water, reduced flooding, aesthetic effects, and other benefits. These benefits are typically more difficult to quantify than the tangible costs of tree planting, but they should be considered in the analysis of economic costs and benefits of riparian afforestation activity.

Table I-13. Economic costs of riparian forest establishment

Year	Acres Planted	Total Cost	Discounted Cost
2008	168	$177,064	$177,064
2009	336	$354,128	$337,265
2010	503	$531,192	$481,807
2011	671	$708,257	$611,819
2012	839	$885,321	$728,356
2013	1,007	$1,062,385	$832,406
2014	1,175	$1,239,449	$924,896
2015	1,343	$1,416,513	$1,006,690
2016	1,510	$1,593,577	$1,078,596
2017	1,678	$1,770,642	$1,141,371
2018	1,846	$1,947,706	$1,195,722
2019	2,014	$2,124,770	$1,242,309
2020	2,182	$2,301,834	$1,281,747
Total	**15,273**		**$11,040,049**

Key Assumptions:

In addition to the assumptions discussed in the narrative above, it was assumed lands that are returned to forest are managed sustainably. Managing and maintaining forested lands is discussed above and under AFW-1.

Key Uncertainties

The actual dollar value of economic benefits of afforestation is difficult to measure. Benefits include ecosystems services, such as clean water, clean air, flood mitigation, aesthetic value, and tourism; thus, these values are not included in the economic analysis that follows.

Cost of land acquisition for planting varies widely.

In North America, freshwater wetlands are complex ecosystems. Carbon storage and CH_4 emissions from these freshwater wetlands are not well understood. In many cases, wetlands are a natural sink for carbon, but can also be a source of CH_4 when decomposition occurs after extended highly anaerobic conditions. Conversely, saltwater marshes are known carbon sinks, but emit negligible amounts of CH_4; the sulfate in saline water suppresses the development of CH_4-generating organisms.

The complexities of these ecosystems make the net carbon equivalent balance (i.e., sinks less GHG outputs) for freshwater wetlands inherently difficult to measure. Saltwater marshes are more straightforward. "The First State of the Carbon Cycle Report"[13] identifies a mean carbon accumulation rate for conterminous United States tidal marshes as 2.2 metric tons per hectare per year (t/ha/year), or 0.9 metric tons per acre per year (t/acre/year).

Research is necessary to reduce the uncertainties in carbon and CH_4 fluxes in wetlands to provide better information on the appropriate management techniques and the potential for GHG emission savings through effective management, restoration, and conservation of wetlands.

Regardless of the type of wetland or the net carbon balance, there are potential risks that significant amounts of carbon stored could be released into the atmosphere if these areas are not appropriately maintained. This highlights the need to preserve and restore these ecosystems, from a GHG and local environmental perspective.

Additional Benefits and Costs

Ancillary benefits from afforestation, such as avoided costs of pollution abatement, are not included in the cost savings. Improvements to barren lands accrued by returning to forestlands include increased local property values due to improved aesthetics, reduced amount and speed of runoff (reducing sedimentation, increasing water quality, and enhancing soil water retention), and improved wildlife habitat.

Feasibility Issues

Timing of implementation depends on funds and policy changes; once trees are planted, it could take 6 to 18 years before measurable carbon sequestration is achieved.

Concern has been expressed that there may not be sufficient acreage to meet the existing and pending offset planting requirements.

Status of Group Approval

Approved.

Level of Group Support

Unanimous.

Barriers to Consensus

None.

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[13] A.W. King, L. Dilling, G.P. Zimmerman, et al., eds. 2008. The first state of the carbon cycle report (SOCCR): the North American carbon budget and implications for the global carbon cycle. A report by the U.S. Climate Change Science Program and the Subcommittee on Global Change Research. National Oceanic and Atmospheric Administration (NOAA), National Climatic Data Center. Available at http://www.climatescience.gov/Library/sap/sap2-2/final-report/default.htm

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

Policy Description

Land conservation offers an important mechanism for mitigating and adapting to climate change. Deforestation and other land-use changes account for as much as 25% of global GHG emissions. In addition, the increasing rate of sea level rise (SLR) and associated erosion threaten Maryland's shoreline and associated coastal wetlands, removing another natural sink for GHGs. For these reasons and more, it is necessary to protect Maryland's network of natural areas (green infrastructure), agricultural lands and coastal lands.

Maryland and its partners should map, designate, prioritize, and purchase areas or property interests that protect green infrastructure and working landscapes, provide carbon sequestration benefits, ensure retreat for wetlands and wildlife from rising waters, and address shoreline erosion issues.

Policy Design

Existing green infrastructure, agricultural lands, and wetlands should be conserved to sequester additional carbon and to avoid emissions associated with development, degradation, or clearing. Forests and farmlands are a major carbon sink, and coastal and riverine wetlands serve as buffers that reduce the impact of storm events and nutrient runoff. These areas should be protected as a GHG mitigation measure.

Green infrastructure is our natural life-support system—an interconnected network of natural areas and other open spaces that maintains fully functioning ecosystems, sequesters CO_2, sustains clean air and water, and provides a wide array of benefits to people and wildlife. These lands include natural and managed forests. 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 of green infrastructure plans includes 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, nongovernmental organizations, and private citizens—to more effectively protect Maryland's green infrastructure network.

Agricultural land provides economic and environmental benefits to the citizens of Maryland, including carbon sequestration in the soil. Due to an alarming loss of prime farmland to development, Maryland intends to preserve sufficient agricultural land to maintain a viable local base of food and fiber production for the present and future citizens of Maryland. Among agricultural practices, no-till farming, residue mulching, cover cropping, and crop rotation enhance carbon sequestration in farm soils. The conservation toolbox for agricultural lands includes many similar tools used for the green infrastructure conservation discussed above.

Wetlands and marshlands protection has been cited as one of the best ways to save lives and prevent property damage in coastal areas. To ensure wetland buffers will be available for Maryland, current wetlands need to be able to move inland as the sea level rises. Without inland areas to which these wetlands can migrate, the Chesapeake Bay's coastal wetlands could simply be drowned by rising Bay waters. Acquisition of lands adjacent to existing tidal marsh in fee simple or by conservation easements is essential for wetlands to migrate landward as sea level rises.

Wetlands with long periods of inundation or surface saturation during the growing season are especially effective at storing carbon in the form of peat, though there are uncertainties associated with carbon storage in wetlands (see Key Uncertainties below). Salt marsh and forested wetlands tend to release less CH_4 than freshwater marsh. Riparian wetlands can also capture carbon washed downstream in litter, branches, and sediment. Because they accumulate sediment and bury organic matter, floodplain and tidal wetlands are especially effective as carbon sinks. These lands also reduce nutrient, sediment, and other pollution into the Chesapeake Bay and other water bodies.

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

Agriculture lands—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.

Forestlands—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. The acreage protected under AFW-4 is additional to acreage already slated for protection under other programs; thus AFW-4 seeks to target upland forest areas, which are at greatest risk of conversion to developed use.

Wetlands—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 CO_2 sequestration. Next using geographic information system (GIS) analysis, predict losses due to climate change and set regional goals for restoration based on predicted losses and funding availability (not quantified).

Coastal lands—Protect priority areas designated for coastal wetland retreat and coastal forestlands using nonstructural shore erosion controls (i.e., living shoreline), keeping pace with wetland, forest, and critical habitat loss due to SLR (not quantified).

Timing: As described above.

Parties Involved: State and quasi-state government agencies including the Maryland Department of Planning (MDP), nonprofit organizations, foundations, and individuals.

Other: Before colonization by Europeans, Maryland was 95% forested, the other 5% being marsh around Chesapeake Bay.[14,15] By 2000, forest had decreased to 42.8% of land cover.

[14] F. W. Besley. The forests of Maryland. Maryland State Board of Forestry, Baltimore, MD. 1916.

Similarly, Maryland has lost 50% of its pre-settlement wetlands.[16] Developed land use reached 509,200 hectares in 2000. The MDP 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% 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 approximately 260 acres of tidal shoreline to erosion each year. Accelerating rates of SLR combined with increased development along Maryland's coastline tend to prolong and exacerbate shore erosion problems.

Implementation Mechanisms

Land Preservation Tax Credit—Modify Existing Income Tax Credit for Preservation and Conservation Easements (Maryland 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 preservation or conservation, agricultural use, forest use, open space, and natural resource conservation. The credit pool would be capped at $100 million/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 or fee title.
  - Landowners with little or no taxable income derive fewer benefits from tax credits than 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/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 Maryland State Department of Assessment and Taxation (SDAT) 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 the consumer price index for all urban consumers (CPI-U) exceeds the previous year's 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 a shoreline restoration and conservation fund.

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[15] D. Powell, N. Kingsley, N. 1980. The forest resources of Maryland. Resource Bulletin NE-61. USDA USFS, Northeastern Forest Experiment Station. 103 p.

[16] R. W. Tiner, and D.G. Burke. 1995. Wetlands of Maryland: U.S. Fish and Wildlife Service, Ecological Services, Region 5, Hadley, Massachusetts and Maryland Department of Natural Resources, Baltimore, Maryland, 408 p.

CO_2 Budget Trading Program

- Prioritize the sequestration of carbon through land conservation or restoration by making a fixed percent of CO_2 emissions proceeds from future Maryland carbon markets exclusively available to land conservation projects.
- Approve Subtitle 26.09 Maryland CO_2 Budget Trading Program, with the 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 Targeting

- One of the state's key implementation tools is 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 been distributed on the basis of a project's GHG 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 Forestland-owners

- Through the Maryland Agriculture and Resource Based Industry Development Corporation (MARBIDCO), provide eligible forestland-owners up to 70% 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 3 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 [MET]).

Forest Conservation Easement Program

- Contribute funds to the Maryland Agricultural Land Preservation Foundation (MALPF) specifically for the protection of forests.
- Funding to quickly implement an aggressive initiative to sequester carbon by avoiding deforestation and growing trees.
- Program modeled on a 2001 effort to provide MALPF with funds to protect land within the green infrastructure network (see HB. 1379), which worked for several years.

Others

- Encourage use of the easements mandated under the FCMA for development projects and the Forest Legacy perpetual easements for working forests.
- Modify income tax policy regarding land conservation credits, cap credit pool at $100 million. Maximum credit suggested is $100 thousand/year. *(Concept: Update tax credit program to be more similar to Virginia to incentivize land conservation.)*

- Generate pool of money from industry-offset allowances; earmark a certain amount specifically for land conservation.
- Encourage local bond initiatives and allow them through state authorization.
- Encourage and support the right of local governments to hold taxes specifically for conservation.
- Increase the transfer tax on agriculture and forestry land transfers to non-agriculture and forestry uses. Maryland Land Preservation Taskforce suggests doubling that tax on conversion of agricultural lands to development.
- Reduce or eliminate transfer taxes for continued agriculture and forestry uses.
- Encourage watershed-based planning as an important tool for accomplishing the goals above.
- Rank POS money by GHG benefit.
- There should be **no** diversion of land conservation funds from POS.

Related Policies/Programs in Place

- DNR's Greenprint Program.
- MDE's Wetlands and Waterways Program.
- POS.
- Rural Legacy Program.
- MALPF.
- MET.
- Maryland Historical Trust.
- Chesapeake Executive Council Forest Conservation Directive (No. 06-1), signed by Governor O'Malley, charged the signatory states to develop quantitative goals for forest protection. For Maryland these goals are to
    - Retain existing levels of forest cover in Maryland, estimated at 2.6 million acres past 2020.
    - 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.
    - Produce rural and forestland retention guidelines based on watershed indicators by 2008 that can support requirements for forest and water protection in local comprehensive plans.

Type(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 Resources Inventory (NRI), Maryland. http://www.md.nrcs.usda.gov/technical/nri.html

Maryland Agricultural Land Preservation Foundation (MALPF). http://www.malpf.info

Farm and Ranch Land Protection Program (FRLPP). http://www.md.nrcs.usda.gov/programs/frpp/frpp.html

J.E. Smith, L.S. Heath, K.E. Skog, and R.A. Birdsey. 2006. Methods for calculating forest ecosystem and harvested carbon with standard estimates for forest types of the United States. USDA USFS Northeastern Research Station. General Technical Report GTR-NE-343. (This document is also published as part of the US DOE 1605(b) Voluntary GHG Reporting Program).

R.A. Birdsey and G.M. Lewis. 2002. Carbon in United States forests and wood products, 1987–1997: state-by-state estimates. Sponsored by the U.S. Environmental Protection Agency (US EPA), IAG DW12938264-01-0, and conducted by the USDA USFS Northern Global Change Research Program. Available at http://www.fs.fed.us/ne/global/pubs/books/epa/index.html

Quantification Methods:

Agriculture Lands GHG Benefit

Studies are lacking on the changes in above- and belowground 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). The Center for Climate Strategies (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 aboveground carbon stocks.

The benefit in each year was derived by

- Determining the amount of land protected in each year by using an estimate of the annual rate of agricultural land lost (11,813 acres/year, determined from National Resources Inventory (NRI) Maryland data)[17] and assuming that agricultural land is protected at an increasing rate up to 2020, when it is assumed there is no net loss of agricultural land;
- Multiplying the soil carbon content (assumed to be 0.017 million metric tons of carbon [MMtC] per 1,000 acres) on the protected land by 50% (representing graded and covered areas) and by 75% (fraction of soil carbon lost); and
- Converting the soil carbon lost to CO_2 by multiplying by 44 by 12.

[17] The most recent NRI data available at the detailed state level is for 1982 to 1997. It is expected that data up to 2003 will be available in 2008.

The GHG benefits are indicated in Table I-14. Note that the GHG benefits include only the changes to belowground soil carbon, and the quantification does not include emissions caused by activities associated with the various land uses (e.g., emissions from tractor activities on agriculture land or urban vehicle activity on developed land).

Agriculture Lands Cost

To estimate program costs in each year, the estimated agricultural acres protected from development were multiplied by the conservation cost. The conservation costs were assumed to be the average easement acquisition cost per acre by MALPF ($5,952/acre).[18] This cost of conservation is assumed to remain constant across the policy period. It is further assumed that subsidies are available through the Farm and Ranch Land Protection Program (FRLPP)[19] for a 50% cost-share. While the administrative structure between MALPF and FRLPP has changed, it is assumed that the cost-share will continue and reduce the conservation costs by 50%.[20] The resulting cost-effectiveness is $87/ton of carbon emissions reduced. This estimate accounts only 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 (VMT). The GHG benefits and program costs are summarized in Table I-14.

[18] Average easement acquisition cost per acre in fiscal year 2007 Easements Purchased by MALPF, from MALPF five-year Annual Report for fiscal years 2003-2007 (January 11, 2008), available at http://www.malpf.info/reports/AR2007Distn.pdf

[19] The FRLPP 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 nongovernmental organizations to acquire conservation easements, or other interests in land from landowners.

[20] Until December 31, 2005, FRLPP matched up to 50% of MALPF's easement value. FRLPP now requires a "before-and-after" appraisal, incorporating a new definition of fair market value that adjusts values for the impact of the easement on adjacent parcels owned by the seller, to calculate the value of the federal match. The FRLPP easement valuation system creates administrative problems for MALPF, but only after a third appraisal is completed close to the time of settlement. This is because the amount of the federal match cannot be determined at the time of the offer, increasing the difficulty of allocating funds among funding sources (MALPF five-year Annual Report for fiscal years 2003-2007, January 11, 2008).

Table I-14. Acreage protected annually and associated avoided emissions and costs under policy implementation

Year	Assumed Percentage of Goal Achievement	Agriculture Acres Protected	$MMtCO_2e$ Saved	Costs	Discounted Costs
2008	8%	909	0.021	$2,704,345	$2,704,345
2009	15%	1,817	0.042	$5,408,689	$5,151,133
2010	23%	2,726	0.064	$8,113,034	$7,358,761
2011	31%	3,635	0.085	$10,817,378	$9,344,458
2012	38%	4,544	0.106	$13,521,723	$11,124,355
2013	46%	5,452	0.127	$16,226,068	$12,713,549
2014	54%	6,361	0.149	$ 8,930,412	$14,126,165
2015	62%	7,270	0.170	$21,634,757	$15,375,418
2016	69%	8,178	0.191	$24,339,102	$16,473,662
2017	77%	9,087	0.212	$27,043,446	$17,432,447
2018	85%	9,996	0.234	$29,747,791	$18,262,563
2019	92%	10,905	0.255	$32,452,135	$18,974,091
2020	100%	11,813	0.276	$35,156,480	$19,576,444
Total		**82,693**	**1.93**		**$168,617,389**

$MMtCO_2e$ = million metric tons of carbon dioxide equivalent.

Forestlands 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; and (2) the amount of annual carbon sequestration potential maintained by protecting the forest area.

1. Maintaining Forest Carbon Sinks

Carbon savings from maintaining forests were calculated using statewide average estimates of the total of standing-forest carbon stocks in Maryland, as provided by the USFS as part of the I&F for Maryland (Appendix H).

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 carbon may be lost on forest conversion to developed use, soil carbon loss was excluded from this analysis because soil carbon dynamics are not included in the baseline calculations for the I&F. A comparison of data from the American Housing Survey with land-use conversion data from the NRI suggests, on average, two-thirds of the land area in residential lots is cleared during land conversion. Thus it was assumed during forest conversion to developed use that 100% of the forest vegetation would be lost on 67% of the converted acreage. Using the statewide average carbon densities from the USFS FIA for Maryland results, roughly 27.9 tons of carbon emissions are avoided for every acre of forest preserved in Maryland.

The best currently available data on transition into and out of the forestland category are from the FIA data set. Based on these data, between 1986 and 1999, roughly 9,643 acres of forest were lost in Maryland annually (FIA statistics). The most recent FIA data on forestland-use transition in Maryland are not reliable because an adequate number of plots have not yet been sampled to provide a statistically robust sample of forestland area. Still, the most recent inventory cycle (in 2006) does suggest a continued loss of forestland in Maryland.

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

Table I-15 shows the annual and total acreage targeted by the program and associated avoided emissions through the retention of forestlands that would be generated between 2008 and 2020.

Table I-15. Acreage protected annually and associated avoided emissions under policy implementation

Year	Acres Protected	Avoided Emissions ($MMtCO_2e$)
2008	19,200	1.962
2009	19,200	1.962
2010	19,200	1.962
2011	19,200	1.962
2012	19,200	1.962
2013	19,200	1.967
2014	19,200	1.967
2015	19,200	1.967
2016	19,200	1.967
2017	19,200	1.967
2018	19,200	1.967
2019	19,200	1.967
2020	19,200	1.967
Total	**250,000**	**25.545**

$MMtCO_2e$ = million metric tons of carbon dioxide equivalent.

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 (USFS FIA). The remaining forestland 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%). Thus, the calculations in this section of the analysis used default carbon sequestration values for these forest types (USFS GTR-NE-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 I-16). Soil carbon density was assumed to be constant and is not included in the calculation.

Table I-16. Forest carbon sequestration rates in protected forests

Forest Type	tC/acre (25 year)	tC/acre (75 year)	tC/acre/year
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

tC/acre = metric tons of carbon per acre.

The results for annual sequestration potential under policy implementation are provided in Table I-17. 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 I-17. Cumulative protected acreage and annual sequestration on protected acreage under policy implementation.

Year	Cumulative Acreage Protected	Annual Sequestration ($MMtCO_2e$)
2008	19,200	0.055
2009	38,400	0.110
2010	57,600	0.165
2011	76,800	0.220
2012	96,000	0.274
2013	115,250	0.329
2014	134,500	0.384
2015	153,750	0.439
2016	173,000	0.495
2017	192,250	0.550
2018	211,500	0.605
2019	230,750	0.660
2020	250,000	0.715
Total	**250,000**	**5.000**

$MMtCO_2e$ = million metric tons of carbon dioxide equivalent.

3. Overall GHG Benefit of Avoided Land Conversion

The cumulative GHG benefit of avoided forestland conversion (including avoided emissions from reduced conversion, as well as annual sequestration in protected forest) was calculated in units of $MMtCO_2e$ (Table I-18). Figure I-1 shows the relative impact of avoided emissions and sequestration in protected acreage.

Table I-18. Combined effect of avoided land conversion and carbon storage on protected acreage

Year	$MMtCO_2e$/year
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**

$MMtCO_2e$ = million metric tons of carbon dioxide equivalent.

Figure I-1. Relative impact of forest protection and carbon sequestration on protected acreage

$MMtCO_2e$/yr = million metric tons of carbon dioxide equivalent per year.

Forestlands Cost

Economic costs of protecting forestland were assumed to be the per-acre one-time cost of purchasing conservation easements at $5,952/acre. This estimate is the recorded average "acquisition cost" in 2007 for easements obtained in Maryland via the MALPF (see Agriculture Land Costs, page AFW-32).

Net economic costs of protecting forestland are presented in Table I-19. Discounted costs were calculated using a 5% discount rate, with a total NPV of $1,128.7 million. The cost-effectiveness of this option is $36.95/t$CO_2$e avoided.

Table I-19. Economic costs of protecting forestland under AFW-4

Year	Total Cost	Discounted Costs
2008	$114,278,400	$114,278,400
2009	$114,278,400	$108,836,571
2010	$114,278,400	$103,653,878
2011	$114,278,400	$98,717,979
2012	$114,278,400	$94,017,122
2013	$114,576,000	$89,773,294
2014	$114,576,000	$85,498,375
2015	$114,576,000	$81,427,024
2016	$114,576,000	$77,549,547
2017	$114,576,000	$73,856,711
2018	$114,576,000	$70,339,725
2019	$114,576,000	$66,990,214
2020	$114,576,000	$63,800,204

Key Assumptions:

The cost of conservation is assumed to remain constant across the policy period.

Key Uncertainties

Carbon storage and CH_4 emissions from wetlands in Maryland (and North America more broadly) are highly uncertain in these complex ecosystems. In many cases, wetlands are a natural sink for carbon, but can also be a source of CH_4 when decomposition occurs after extended highly anaerobic conditions. Other wetlands, such as saltwater marshes, are different; they support carbon sequestration, but emit negligible amounts of CH_4 because sulfate in saline water suppresses the development of CH_4-generating organisms.

The complexities of these ecosystems make the net carbon equivalent balance (i.e., sinks less GHG outputs) for fresh water wetlands inherently difficult to measure. Saltwater marshes are more straightforward and "The First State of the Carbon Cycle Report"[21] identifies a mean

[21] A.W. King, L. Dilling, G.P. Zimmerman, et al., eds. 2008. The first state of the carbon cycle report (SOCCR): the North American carbon budget and implications for the global carbon cycle. A report by the U.S. Climate Change Science Program and the Subcommittee on Global Change Research. NOAA, National Climatic Data Center. Available at http://www.climatescience.gov/Library/sap/sap2-2/final-report/default.htm

carbon-accumulation rate for conterminous United States tidal marshes as 2.2 million grams of carbon per hectare per year (gC/ha/year).

Research is necessary to reduce the uncertainties in carbon and CH_4 fluxes in wetlands to provide better information on the appropriate management techniques and the potential for GHG emission savings through effective management, restoration, and conservation of wetlands.

Regardless of the type of wetland or the net carbon balance, there are potential risks that significant amounts of carbon stored could be released into the atmosphere if these areas are not appropriately maintained. This highlights the need to preserve and restore these ecosystems, from a GHG and local environmental perspective.

Additional Benefits and Costs

One highly beneficial aspect of land conservation is the protection of ecosystem services. These services (e.g., carbon sequestration, cleaning the air, filtering and cooling water, storing and cycling nutrients, conserving and generating soils, pollinating crops and other plants, protecting areas against storm and flood damage, and maintaining hydrologic regimes) are all provided by the existing expanses of forests, wetlands, and other natural lands.[22] These ecologically valuable lands also provide marketable goods and services, like forest products, fish and wildlife, and recreation. They serve as vital habitat for wild species, maintain a vast genetic library, provide scenery, and contribute in many ways to human health and quality of life.

When wetlands and forest are utilized for development, there are costs incurred that are typically not accounted for in the marketplace. The losses in ecosystem services are hidden costs to society. These services, such as cleansing the air and filtering water, meet fundamental needs for humans and other species, but in the past, the resources providing them were so plentiful and resilient that they were largely taken for granted. In the face of a tremendous rise in population and land consumption, these natural or ecosystem services must be afforded greater consideration. The breakdown in ecosystem functions causes damages that are difficult and costly to repair, as well as taking a toll on the health of plant, animal, and human populations.[23] Though difficult to calculate, ecosystem services should be part of a benefit costs analysis because they would add significant benefit to land conservation decisions.

It is difficult to calculate the carbon benefits of coastal land conservation and retreat policies. Nevertheless, the benefits can and should be calculated in human lives and dollars saved.

Feasibility Issues

Land conservation is a common practice in America. There is a clear role that land conservation plays in solving the climate crisis in carbon sequestration and adaptation. Other than funding, there are few limitations to implementation.

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[22] R. Costanza et.al. 1997. The value of the world's services and natural capital. *Nature* 387:253-259.

[23] R.J. Orth, R.A. Batiuk, P.W. Bergstrom, and K A. Moore. 2002. A perspective on two decades of policies and regulations influencing the protection and restoration of submerged aquatic vegetation in Chesapeake Bay, USA. Bull. Mar. *Science* 71 (3): 1391-1403.

Status of Group Approval

Approved.

Level of Group Support

Unanimous.

Barriers to Consensus

None.

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

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

Goals:

Farmers' Market—Increase the number of local farmers' markets in Maryland 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: Start up 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, farmers' 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-yourself products, architects and designers; applicable trade associations; MDA; DNR; and Leadership in Energy and Environmental Design (LEED) certification entities.

Other: Identify incentives that encourage the sustainable growing and harvesting of local agricultural and wood products.

Implementation Mechanisms

Specific incentives recommended include the following:

- 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.
- Encourage the development of certification programs for sustainably harvested wood products from state and private lands. Certification programs exist for organically produced and raised products, but there are local certification programs that could be developed to assure consumers that produce and animal products are sustainably raised.
- Maryland has been a LEED (a rating and certification system for green building) leader, but has not 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. Maryland should push for LEED to include points for the use of wood, particularly local sustainably grown wood.
- Encourage the creation of value-added products from local woods in lieu of shipping raw materials from long distances.
- Provide education for producers in marketing techniques and effective local distribution.

Related Policies/Programs in Place

MDA has recently been revitalized and is actively promoting a Buy Local program.

Type(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

Data Sources:

All data sources, methods, and assumptions are based on a study by Iowa State University (ISU),[24] and were scaled to Maryland using state population adjustments. The study analyzed the feasibility and effects of shifting transportation distance and modes.

Quantification Methods:

Farmers' Market GHG Benefits

The GHG benefits for the Maryland option are based on the ISU study that compared miles traveled, fossil fuel used, and CO_2 emitted in the transport sector of several food systems. The

[24] R. Pirog. 2001 (June). Food, fuel, and freeways: an Iowa perspective on how far food travels, fuel usage, and GHG emissions. Leopold Center for Sustainable Agriculture, ISU. Available at http://www.leopold.iastate.edu/

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 farmers' 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 I-20. The 2006 population estimates were based on U.S. Census Bureau data for Iowa and Maryland[25]—2,982,085 as the population for Iowa and 5,615,727 for Maryland.

Table I-20. Fuel consumption and emissions from the Iowa study and the assumed scaling for Maryland

Food System and Type of Truck	Fuel Consumption (gal/year)	CO_2 Emissions (t/year)
Iowa conventional tractor-trailer	368,102	3,807
Iowa local—Community Supported Agriculture (CSA) farmers' market small truck (gas)	49,359	439
Maryland conventional tractor-trailer	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

gal/year = gallons per year; CO_2 = carbon dioxide; t/year = metric tons per year.

Table I-21 presents the GHG savings from increasing the proportion of produce sold at farmers' markets.

[25] See http://quickfacts.census.gov/qfd/states/19000.html and http://quickfacts.census.gov/qfd/states/24000.html

Table I-21. GHG savings from increasing the proportion of produce sold at farmers' markets

Year	Increase in Local Farmers' Markets	tCO_2e
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
Cumulative		**198,205**

tCO_2e = metric tons of carbon dioxide equivalent.

Farmers' Market Costs

Costs to administer this program and the possible incentives required to increase the number of farmers' markets in Maryland are difficult to determine, and further work in this area is required. For the purposes of quantification, it was assumed that the program costs will be similar to those required to implement the Farm-to-School Program.[26] The breakdown of the expenditures for the first year is presented in Table I-22.

Table I-22. Farm-to-school program future year expenditure estimates

Type of Expenditure	Costs
Positions	1.5
Salaries and fringe benefits	$82,288
Contractual services	$27,500
Equipment	$4,200
Operating expenses	$9,246
Total state expenditures	**$123,234**

The above estimates are based on one full-time position within the Maryland State Department of Education (MSDE) and one and a half positions within MDA to coordinate the Farmers'

[26] A fiscal and policy note on this program has recently been submitted to the Maryland General Assembly (HB 696).

Market program, based on the costs required to implement the Farm-to-School program.[27] While the Farm-to-School Program is not identical to the Farmers' Market program, it serves as a good proxy for estimating the program costs—noting that other costs, such as additional costs to incentivize local year-round production of agricultural products, as well as regional storage, processing, packaging, and distribution, have not been included in this analysis.

In addition to the program costs and incentives required, there are also likely to be cost savings associated with reduced fuel used in transporting non-local produce. The price of gasoline was assumed to be $3.00 per gallon (/gal). Table I-23 summarizes the potential costs and costs savings of the farmers' market component.

Table I-23. Costs and savings from farmers' market expansion under AFW-5

Year	Fuel Saved (gal/year)	Program Costs[28]	Fuel Savings	Net Costs	Discounted Costs
2008	187,576	$123,234	$562,727	–$439,493	–$398,633
2009	375,151	$134,000	$1,125,454	–$991,454	–$856,456
2010	562,727	$140,000	$1,688,182	–$1,548,182	–$1,273,693
2011	750,303	$146,200	$2,250,909	–$2,104,709	–$1,649,094
2012	937,879	$152,800	$2,813,636	–$2,660,836	–$1,985,557
2013	1,125,454	$159,676	$3,376,363	–$3,216,687	–$2,286,040
2014	1,313,030	$166,861	$3,939,090	–$3,772,229	–$2,553,193
2015	1,500,606	$174,370	$4,501,818	–$4,327,447	–$2,789,511
2016	1,800,727	$182,217	$5,402,181	–$5,219,964	–$3,204,605
2017	2,100,848	$190,417	$6,302,545	–$6,112,128	–$3,573,635
2018	2,400,969	$198,985	$7,202,908	–$7,003,923	–$3,900,046
2019	2,701,091	$207,940	$8,103,272	–$7,895,332	–$4,187,063
2020	3,001,212	$217,297	$9,003,635	–$8,786,338	–$4,437,698
Total					**–$33,095,223**

gal/year = gallons per year.

Note: Other costs, such as additional costs to incentivize local year-round production of agricultural products, as well as regional storage, processing, packaging, and distribution, have not been included in this analysis.

Locally Grown and Processed Lumber: GHG Benefits and Economic Costs

If the amount of lumber used in-state remains constant, and if there is no increase in lumber produced from in-state sources, then a switch from imported to domestic lumber would result in GHG benefits from transportation of domestic lumber that would otherwise have been imported.

[27] Costs include salaries, fringe benefits, one-time start-up costs, and ongoing operating expenses. Future years (2010–2013) reflect 4.4% annual increases in salaries, 3% employee turnover and 2% annual increases in ongoing operating expenses.

[28] After 2013, the program costs were assumed to increase at a rate of 4.5% per annum to account for increases to salary expenses and operating expenses.

Because these benefits are likely to be difficult to quantify and also quite negligible, GHG benefits from this component of AFW-5 are not quantified.

Key Assumptions:

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

Additional costs to incentivize local year-round production of agricultural products, as well as regional storage, processing, packaging, and distribution, have not been included in this analysis.

Key Uncertainties

- The largest 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 with those in Iowa are not included in this analysis.
- There is a difference in the life cycle GHG emissions between organically grown and chemically supported crops. Quantifications reflect an average emission reduction by crop.
- The differences in cost of growing food locally versus elsewhere (as determined by market) have not been incorporated.
- Incentive system required to make producer and consumer shifts must be viable.

Additional Benefits and Costs

There is a plethora of direct and indirect social, health, and economic benefits accrued from marketing local goods.

Modern society and technology have made it possible to live isolated lives where purchasing is done remotely or in large impersonal stores with uniform merchandise. By creating markets and gathering places where positive exchanges for goods and services are made face-to-face, community contact is reestablished. These social networking opportunities foster a sense of belonging and community pride that can lead to further local commercial engagements and volunteerism within the community.

Shortening the chain and distance between producer and consumer puts more money directly in the pocket of producers within the community. The community benefits from this localized exchange by keeping dollars circulating within the community instead of being a net-exporter of capital. Consumers are often willing to pay a small premium in exchange for fresher produce and local hand-crafted artisan wares.

Research suggests fresh produce contains higher nutritional content than older produce, which contributes to more robust health. Consumers concerned about food growing practices and handling can make inquiries to the producers directly, and even ascertain and demand sustainable harvest of wood products, which would lead to a healthier environment.

Reductions in packaging produce significant energy, material, and waste reductions. (Transportation saving in energy and carbon emissions has already been quantified above.)

Varieties of crops phased out of commercial production because of vulnerability to the rigors of mechanical handling and long transports, or non-uniform appearance and size, can now be reintroduced to the market. Expanding the gene pool and species diversity benefits producers by reducing crop failures associated with disease and infestation of monocultures, as well as being able to offer "boutique" lines of produce. Consumers benefit by an increase of choice and tastes, which in turn increases consumption of fresh produce, an important part of a healthy diet.

Local producers come to know one another and can exchange production and marketing tips that are uniquely effective under local conditions. Cooperatives may be formed to enhance marketing through common distribution points and other economies of scale.

Greater utilization of local wood for more highly valued products encourages reduction of fuels that could exacerbate forest fires, provides living wage jobs in the region, improves forest health, and allows cost-effective utilization of residual biomass.

Policies that encourage institutional or commercial purchase of local food and wood products expand the demand providing even greater financial incentives for higher production and guaranteed revenues. Accordingly, more land will be kept in active, economically viable agricultural and forest management, which contributes to meeting other carbon-reduction policy options encouraging protection and conservation of these lands as an alternative to development.

Feasibility Issues

This analysis has addressed only the farmers' 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% 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 processed locally would result in significantly higher GHG emission reductions from transport.

Status of Group Approval

Approved.

Level of Group Support

Unanimous.

Barriers to Consensus

None.

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

Policy Description

Sustainable forest and farm practices produce by-products and feedstocks (for example, chicken litter, CH_4, slash, switchgrass, and corn stalks), which were earlier considered unsuitable for further use. They can be sources of renewable energy. This policy option should increase the utilization of biomass from urban and rural feedstocks, including processing by-products for generation of electricity, thermal energy, and transportation fuels. Additionally, this option should reduce the amount of CH_4 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 feedstocks and by-products are used to create heat or power, which offsets production of fossil fuel-based energy and associated GHG emissions. Shortfalls in biomass feedstocks may be met by municipal solid waste (MSW), such as paper, cardboard, organics, and yard waste. Ensure that these stocks are not already being used for other higher value products before counting all stocks as being available.

Note: This option was quantified on the basis of utilization of 25% of crop residues and 50% of forestry residues by 2020 as a biomass energy source. AFW-7 was quantified using 100% of available residues. AFW-7 has subsequently been dismissed as a recommended policy option under AFW due to lack of sufficient biomass, once all food stocks as biomass were eliminated.

Policy Design

- All biomass products will be sustainably harvested without depriving soils of important organic components for reducing erosion, but will maintain soil nutrients and structure, and will not deplete wildlife habitat or jeopardize future feedstocks in quantity or quality.
- Install manure digesters and energy recovery projects in hog, dairy, and poultry operations. Community and multi-facility digesters are far more cost-efficient than units on individual operations.
- The life cycle energy costs and carbon emissions for each feedstock will be evaluated.

Goals:

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

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

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

CH_4 from Livestock Manure and Poultry Litter—By 2020, utilize 50% of available CH_4 from livestock manure and poultry litter for renewable electricity, heat, and steam generation.

Timing: As described above.

Parties Involved: Maryland Energy Administration (MEA), DNR, MDE, MDA, municipalities, power producers (such as Mirant and Constellation), local electric utilities (and distributors), Maryland State Board of Education, energy consumers in rural communities (hospitals, community colleges, and universities), Soil Conservation Districts.

Implementation Mechanisms

- Provide outreach and education.
- Change present laws to add incentives (e.g., the Maryland Clean Energy Act).
- Increase incentives through programs (e.g., Fuels for Schools, tax-forgiveness).
- Maryland Department of General Services (DGS) should provide equal credit to efficient design and energy-efficiency loan programs.
- DGS should afford equal treatment for wood-based energy systems as other renewable energy systems.
- Establish incentives for utilizing renewable heating fuels (e.g., tax credits similar to those afforded electricity producers by the Maryland Clean Energy Act).
- Acknowledge that Maryland energy policy is devoid of any discussion regarding thermal loads, which represent 40% of Maryland's total energy budget.

Related Policies/Programs in Place

Modify the Renewable Portfolio Standards (RPS) that requires local sources of renewable energy.

Type(s) of GHG Reductions

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

Estimated GHG Reductions and Net Costs or Cost Savings

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 biomass will replace coal. This is based on the assumption that biomass will be used to replace coal in the RCI and electricity sector (where coal represents the majority of electricity generated).[29] While co-firing was used as a technology to provide an estimate of possible capital costs that would be required to enable the utilization of biomass, it is recognized that other technologies (e.g., gasification) potentially offer more significant opportunities. (Currently, co-firing is feasible at only two power plants in Maryland.)

With the exception of available urban wood waste, the amount of biomass available is taken from the DNR document titled "The Potential for Biomass Co-firing in Maryland."[30] Available agriculture biomass is indicated in Table I-24 and available biomass from forests is indicated in Table I-25. The amount of available energy crop estimated in "The Potential for Biomass Co-firing in Maryland" assumed that 25% of idle cropland (approximately 51,307 acres in Maryland) is used to grow switchgrass (this translates to approximately 250,000 dry tons of switchgrass fuel).

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

[30] Maryland DNR. 2006 (Mar.).The potential for biomass cofiring in Maryland. Prepared by Princeton Energy Resources International, LLC and Exeter Associates Inc. for the DNR Maryland Power Plant Research Program. Available at http://esm.versar.com/pprp/bibliography/PPES_06_02/PPES_06_02.pdf

Table I-24. Available biomass from agriculture feedstocks

Agriculture Feedstocks	Dry Tons	Heat Content (MMBtu/ton)[31]	Estimated Heat Input (MMBtu)
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**

MMBtu = million British thermal units.

Table I-25. Available biomass from forestry feedstocks

Forestry Feedstocks	Dry Tons	Heat Content (MMBtu/ton)	Estimated Heat input (MMBtu)
Forest residue	136,878	9.6	1,314,029
Mill residue	148,754	14	2,082,556
Urban residue[32]	526,713	10	5,267,132
Total forest feedstocks	**812,345**		**8,663,717**

MMBtu = million British thermal units.

Biomass is assumed to have a reduction of 0.0940 tCO_2e per MMBtu, when replacing coal combustion.

Biomass Costs

The two main components to the calculation are fuel costs and capital costs. The fuel component is based on the difference in costs between supply of biomass fuel and the assumed fossil fuel it is replacing (i.e., coal). The assumed costs are identified in Table I-26 and have been taken from "The Potential for Biomass Co-firing in Maryland."[33]

[31] Heat content of agricultural by-products 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 EIA Annual Energy Outlook 2005 (Feb.), Table H1.

[32] Available urban wood waste is based on analysis by Daniel Rider, Maryland DNR Forest Service. Mr. Rider's analysis indicated that urban wood sourced from refuse (e.g., construction and demolition, pallets, landfill segregates), arborists, and land clearing totaled approximately 810,328 tons of fresh "natural" wood each year. Moisture content of 35% was assumed to derive the estimate of 526,713 dry tons per annum.

[33] Maryland DNR. 2006 (Mar.). The potential for biomass cofiring in Maryland. Prepared by Princeton Energy Resources International, LLC and Exeter Associates Inc. for the DNR Maryland Power Plant Research Program. Available at http://esm.versar.com/pprp/bibliography/PPES_06_02/PPES_06_02.pdf

Table I-26. Assumed costs of feedstocks

Fuel Type	Cost $/Ton Delivered	Cost $/MMBtu Delivered
Agricultural by-products	$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

$/Ton = dollars per ton; $/MMBtu = dollars per million British thermal units.

The cost is calculated by assuming the replacement of coal with biomass. The difference in cost of supply between biomass and coal is calculated using the costs indicated in Table I-26. The difference in costs (dollars per MMBtu [$/MMBtu]) is multiplied by the amount of coal energy (MMBtu) being replaced by biomass. The assumed incremental capital costs are based on the capital costs associated with retrofitting an existing 300–700 MW capacity coal-fired boiler. An average capital cost of $180 per kilowatt (kW) was assumed, based on the range ($150–$200/kW) provided in "The Potential for Biomass Co-firing in Maryland." While use of biomass may be pursued through other technology types (e.g., gasification) or end-uses (e.g., heat or steam), the capital costs of co-firing were used to provide an estimate of possible capital costs required to enable the utilization of biomass.[34]

The capital infrastructure lifespan was assumed to be 30 years, and the interest rate was assumed to be 5%, giving a capital recovery factor of 0.065 (i.e., a $1 million plant is assumed to cost approximately $65,000/year over the life of the project). For the purposes of this analysis, it is assumed that biomass plants do not require additional operating and maintenance costs (e.g., no additional emission control measures or ash disposal are required).

Table I-27 displays GHG benefits and fuel costs for agricultural residue, Table I-28 displays the same for energy crops, and Table I-29 addresses benefits and costs for forestry feedstocks. A summary of avoided emissions and cost for all biomass components is presented in Table I-30.

[34] The capital costs associated with using biomass as an alternative to fossil-based generation are dependent on many factors, including the end-use (i.e., electricity, heat, or steam), the design and size of the systems, the technology employed, and the configuration specifications of the system. Each system implemented under this policy would require a detailed analysis (incorporating specific engineering design and costs aspects) to provide a more accurate cost estimate of the system.

Table I-27. GHG benefits and fuel costs for agriculture residue

Year	Percent of Utilization	Agriculture Residue Biomass (MMBtu)	Avoided Emissions Agriculture Residue ($MMtCO_2e$)	Agriculture 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
Cumulative Total			**0.620**		**$15,093,364**

MMBtu = million British thermal units; $MMtCO_2e$ = million metric tons of carbon dioxide equivalent.

Table I-28. GHG benefits and fuel costs for energy crops

Year	Percent of Utilization	Total Energy Crops (MMBtu)	Avoided Emissions, Energy Crops ($MMtCO_2e$)	Agriculture Residue Cost/Savings	Discounted Cost/Savings
2008	2%	73,800	0.007	$132,101	$119,820
2009	4%	147,599	0.014	$264,203	$228,228
2010	6%	221,399	0.021	$396,304	$326,040
2011	8%	295,198	0.028	$528,405	$414,019
2012	10%	368,998	0.035	$660,506	$492,880
2013	15%	553,497	0.052	$990,759	$704,114
2014	20%	737,996	0.069	$1,321,013	$894,113
2015	25%	922,495	0.087	$1,651,266	$1,064,421
2016	30%	1,106,994	0.104	$1,981,519	$1,216,481
2017	35%	1,291,493	0.121	$2,311,772	$1,351,645
2018	40%	1,475,992	0.139	$2,642,025	$1,471,178
2019	45%	1,660,491	0.156	$2,972,278	$1,576,263
2020	50%	1,844,990	0.173	$3,302,531	$1,668,003
Cumulative Total			**1.010**		**$11,527,205**

MMBtu = million British thermal units; $MMtCO_2e$ = million metric tons of carbon dioxide equivalent.

Table I-29. GHG benefits and fuel costs for forestry feedstocks

Year	Percentage of Utilization	Forest Feedstocks (Includes Forest and Mill Residue and Urban Wood Waste) (MMBtu)	Avoided Emissions All Forest Feedstocks ($MMtCO_2e$)	Forest Feedstock (Includes Forest and Mill Residue and Urban Wood Waste) Cost/Savings	Discounted Cost/Savings
2008	1%	108,296	0.010	$69,423	$62,969
2009	3%	216,593	0.020	$138,846	$119,940
2010	4%	324,889	0.031	$208,268	$171,343
2011	5%	433,186	0.041	$277,691	$217,578
2012	6%	541,482	0.051	$347,114	$259,022
2013	8%	649,779	0.061	$416,537	$296,025
2014	9%	758,075	0.071	$485,959	$328,916
2015	10%	866,372	0.081	$555,382	$358,004
2016	13%	1,126,283	0.106	$721,997	$443,243
2017	16%	1,386,195	0.130	$888,612	$519,553
2018	19%	1,646,106	0.155	$1,055,226	$587,589
2019	22%	1,906,018	0.179	$1,221,841	$647,968
2020	25%	2,165,929	0.204	$1,388,455	$701,264
Cumulative Total			**1.038**		**$4,713,415**

MMBtu = million British thermal units; $MMtCO_2e$ = million metric tons of carbon dioxide equivalent.

Table I-30. Summary of GHG benefits and costs for biomass

Year	Total Biomass Use (Agriculture Residue, Forest Feedstocks and Energy Crops) (MMBtu)	Annualized Capital Costs	Fuel Costs (Agriculture Residue, Forest Feedstocks and Energy Crops)	Total Costs	Discounted Cost/Savings	Total GHG Emissions Avoided ($MMtCO_2e$)
2008	246,720	$37,031	$423,831	$460,861	$418,015	0.023
2009	493,440	$74,061	$847,661	$921,723	$796,219	0.046
2010	740,160	$111,092	$1,271,492	$1,382,584	$1,137,455	0.070
2011	986,880	$148,123	$1,695,322	$1,843,445	$1,444,387	0.093
2012	1,233,600	$185,153	$2,119,153	$2,304,306	$1,719,509	0.116
2013	1,591,020	$238,799	$2,741,136	$2,979,935	$2,117,784	0.150
2014	1,948,439	$292,445	$3,363,118	$3,655,563	$2,474,229	0.183
2015	2,305,859	$346,090	$3,985,101	$4,331,191	$2,791,924	0.217
2016	2,905,367	$436,072	$5,015,504	$5,451,576	$3,346,795	0.273
2017	3,504,875	$526,053	$6,045,908	$6,571,961	$3,842,489	0.329
2018	4,104,383	$616,034	$7,076,311	$7,692,346	$4,283,386	0.386
2019	4,703,891	$706,016	$8,106,715	$8,812,731	$4,673,579	0.442
2020	5,303,399	$795,997	$9,137,119	$9,933,115	$5,016,898	0.499
Cumulative Total					**$34,062,670**	**2.83**

MMBtu = million British thermal units; $MMtCO_2e$ = million metric tons of carbon dioxide equivalent.

CH_4 Utilization from Livestock Manure and Poultry Litter GHG Benefits

CH_4 emissions (in $MMtCO_2e$) data from the Maryland GHG I&F[35] was used as the starting point to estimate the GHG benefits of capturing and controlling the volumes of CH_4 targeted by the policy and to include the additional benefit of electricity generation using this captured CH_4 (through offsetting fossil-based generation). The first portion of GHG benefit is derived from reduced CH_4 emissions through the capture of emissions from manure and poultry litter. An assumed collection efficiency of 75%[36] was applied to CH_4 emissions from manure and poultry litter, 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 from offsetting fossil-based electricity generation, which was estimated by converting the CH_4 captured in each year to its heat content (in British thermal units [Btus]), and then multiplying by an energy recovery factor of 17,100 Btu per kilowatt hour (kWh) to estimate the electricity produced (assumes a 25% efficiency for conversion to electricity in an engine and generator set). To estimate the CO_2e associated with

[35] Prepared by the CCS for this report. The final version will be published as part of this report, and will be posted at http://www.mdclimatechange.us

[36] The collection efficiency is an assumed value based on engineering judgment. No applicable studies were identified that provided information on CH_4 collection efficiencies achieved using manure digesters (as it relates to collection of entire farm-level emissions).

this amount of electricity in each year, the kWh were converted to megawatt hours (MWh), and this value was then multiplied by the Maryland-specific emission factor for electricity production from the US EPA's Emissions & Generation Resource Integrated Database (eGRID) (0.587 t/MWh).

The total GHG benefit was estimated as the sum of portions of the benefit described above and indicated in Table I-31.

Table I-31. GHG benefits for CH_4 utilization from livestock manure

Year	CH_4 Emissions From Dairy, Swine and Poultry ($MMtCO_2e$)	Policy Utilization Objective	CH_4 Captured and Utilized Under Policy ($MMtCO_2e$)	$MMtCH_4$	CH_4 (MMBtu)	tCO_2e Offset as Electricity	Total Emission Reductions ($MMtCO_2e$)
2008	0.090	4%	0.003	0.000	6547	225	0.003
2009	0.090	8%	0.005	0.000	13,050	448	0.006
2010	0.090	12%	0.008	0.000	19,515	669	0.008
2011	0.090	15%	0.010	0.000	25,977	891	0.011
2012	0.090	19%	0.013	0.001	32,417	1,112	0.014
2013	0.089	23%	0.015	0.001	38,837	1,332	0.017
2014	0.089	27%	0.018	0.001	45,236	1,552	0.020
2015	0.089	31%	0.021	0.001	51,613	1,770	0.022
2016	0.089	35%	0.023	0.001	57,957	1,988	0.025
2017	0.089	38%	0.026	0.001	64,276	2,205	0.028
2018	0.089	42%	0.028	0.001	70,573	2,421	0.031
2019	0.088	46%	0.031	0.001	76,846	2,636	0.033
2020	0.088	50%	0.033	0.002	83,095	2,850	0.036

GHG = greenhouse gas; CH_4 = methane; $MMtCO_2e$ = million metric tons of carbon dioxide equivalent; $MMtCH_4$ = million metric tons of methane; MMBtu = million British thermal units; tCO_2e = metric tons of carbon dioxide equivalent.

CH_4 Utilization from Livestock Manure Costs

The costs for the dairy and swine components were estimated using an NRCS analysis titled "An Analysis of Energy Production Costs from Anaerobic Digestion Systems on U.S. Livestock Production Facilities."[37] The production costs were assumed to be $0.11/kWh for swine anaerobic digesters and $0.05/kWh for dairy anaerobic digesters.[38] These costs are in 2006 dollars and assume a 30% thermal efficiency. The costs include annualized capital costs for the digester, generator, and O&M costs.[39] The "Availability of Poultry Manure as a Potential Bio-

[37] J.C. Beddoes, K.S. Bracmort, R.T. Burns and W.F. Lazarus. 2007 (Oct.). An analysis of energy production costs from anaerobic digestion systems on U.S. livestock production facilities. NRCS. Technical Note No. 1.

[38] It was assumed that the technology employed for swine and dairy anaerobic digesters was covered anaerobic lagoon. Cost was obtained from Table 1 of the NRCS paper sited above.

[39] The economic analysis conducted by Beddoes et al. does not include feedstock and digester effluent transportation costs. The technical note does not address the economics of centralized digesters where biomass is collected from several farms and then processed in a single unit.

Fuel Feedstock for Energy Production," by J.R.V. Flora, and C. Riahi-Nezhad, provided the assumed costs for the poultry component ($0.103/kWh in 2005 dollars using of Anaerobic Digestion).[40] The value of electricity produced was taken from the all-sector average projected electricity price for the Southeastern Electric Reliability Council from the US DOE Energy Information Administration (EIA) "2007 Annual Energy Outlook" (see http://www.eia.doe.gov/oiaf/aeo/supplement/index.html). This price represents the value to the farmer for the electricity produced (to offset on-farm use) and is netted out from the production costs to estimate net costs. Total costs are indicated in Table I-32.

Table I-32. Costs for CH_4 utilization from livestock manure

Year	Cost of Dairy Technology (2006 $)	Cost of Swine Technology (2006 $)	Cost of Poultry Technology (2006 $)	Total Costs (2006 $)
2008	–$5,718	$1,270	$3,841	–$607
2009	–$11,469	$2,509	$7,717	–$1,243
2010	–$17,271	$3,714	$11,615	–$1,942
2011	–$21,892	$5,122	$16,059	–$710
2012	–$25,637	$6,667	$20,958	$1,988
2013	–$29,373	$8,209	$25,854	$4,690
2014	–$33,475	$9,689	$30,546	$6,759
2015	–$37,722	$11,141	$35,150	$8,568
2016	–$43,003	$12,421	$39,158	$8,577
2017	–$48,803	$13,611	$42,866	$7,675
2018	–$54,643	$14,789	$46,530	$6,677
2019	–$59,150	$16,180	$50,898	$7,928
2020	–$63,936	$17,520	$55,096	$8,680
Total				**$57,041**

CH_4 = methane; $ = dollars.

Key Assumptions:

The fuel mix being replaced by biomass is assumed to be 100% coal. Biomass is assumed to have a reduction of 0.0940 tCO_2e/MMBtu when replacing coal combustion. CH_4 utilization is assumed to replace electricity.

While energy production from biomass may be pursued through other technology types (e.g., gasification) or end-uses (e.g., heat or steam), the capital costs of co-firing were used to provide an estimate of possible capital costs required to enable the utilization of biomass. This analysis assumes that on average the capital costs will be similar to those with retrofitted co-fired boiler systems that have a 300–700 MW capacity.

[40] J.R.V. Flora and C. Riahi-Nezhad. 2006 (Aug.). Availability of poultry manure as a potential bio-fuel feedstock for energy production. Department of Civil and Environmental Engineering, University of South Carolina (USC).

The capital costs associated with using biomass as an alternative to fossil-based generation are dependent on many factors, including the end-use (i.e., electricity, heat, or steam), the design and size of the systems, the technology employed, and the configuration specifications of the system.

Each system implemented under this policy would require a detailed analysis (incorporating specific engineering design and costs aspects) to provide a more accurate cost estimate of the system. Similar issues also surround the production of energy from livestock manure and poultry litter.

Key Uncertainties

Energy crops are not widely produced in Maryland, because of the opportunity cost involved in switching to higher-value agriculture products such as corn, wheat, and barley. "The Potential for Biomass Cofiring in Maryland" notes "it is unlikely that a large percentage of local farmers will switch to bioenergy crops absent a subsidy or incentive to encourage the production of energy crops."

The quantity of forest biomass available is more predictable, and is expected to increase over time. However, exact values are uncertain.

Additional Benefits and Costs

The expansion of crops as an energy feedstock needs to ensure energy crops are grown on appropriate land and in ways that do not damage terrestrial or aquatic resources, or displace food and fiber production.

Combustion of animal wastes, rather than liquefaction and subsequent spraying on fields, will reduce waster use, nitrogen release, and the amount of aerosols and particulates released as pollutants.

Feasibility Issues

The feasibility of installing digesters on a small-scale farm is uncertain, and the costs may make this unattractive. Digester facilities tend to require a critical number of animals before the projects are feasible. Thus, implementation at the community or cooperative scale may be more feasible and realistic.

The economical and technical feasibility of using biomass energy as a replacement for conventional energy was not considered as a part of this analysis.

Status of Group Approval

Approved.

Level of Group Support

Unanimous.

Barriers to Consensus

None.

AFW-7. In-State Liquid Biofuels Production

Policy Description

Promote sustainable in-state production and consumption of transportation biofuels, including ethanol and bio-diesel from agriculture 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 are to be achieved. Upon successful implementation of this policy, Maryland consumption of biofuels that are produced in-state will provide better GHG benefits than these same fuels obtained from a national market because of lower embedded CO_2 (due to transportation of bio-diesel, ethanol, other fuels, or their feedstocks from distant sources).

Note: After lengthy discussion and full quantification, it was determined this policy option would not include any feedstocks that could be used as food or animal feed in the total GHG emission reductions or costs, because the unintended consequences of land conversion, food price increases, and using feedstocks with high embodied energy or GHG emissions were deemed counterproductive. In particular, the MCCC's MWG determined that using food source materials would be detrimental to consumers and to balanced and diverse crop production. There is considerable research supporting each side of the argument with no clear conclusions. With the elimination of food-based feedstocks, the sustainability of a massive switch to biofuels on a commercial level appears marginal.

Note: This option is linked with TLU policy recommendation TLU-4, which focuses on the demand-side aspects of a Low Carbon Fuels Standard (LCFS). This AFW option seeks to achieve incremental GHG benefits from the supply side by promoting in-state production of biofuels using feedstocks with greater GHG benefits than the likely BAU national production methods.

Policy Design

Goals:

Gasoline displacement goals—Achieve in-state cellulosic ethanol production equivalent to offsetting gasoline consumption in the state by 3.0% in 2015 and 3.0% in 2020.

Fossil diesel displacement goals—Increase in-state bio-diesel production from Maryland non-food feedstocks to offset diesel consumption in the state by 2% in 2015 and 2.2% in 2020.

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.

The timeline needs to allow time for permitting and construction of sufficient production facilities to meet the goals.

Parties Involved:

Suppliers of feedstocks, ethanol producers, distributors, communities adjacent to potential facilities, and environmental groups. Associated agencies would include DNR, MEA, MDA, Maryland Department of Business and Economic Development (DBED), and MDE.

Other:

Currently, there is one small commercial cellulosic ethanol plant in the United States located in Upton, Wyoming. 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, but not in Maryland. The only ethanol plants proposed in Maryland are corn-based plants.

There are two bio-diesel plants in the state, with production totaling 5 million gallons per year (gal/year).

Impact studies on the effects of gas specification changes, including vapor pressure and O_3 emissions, are needed.

Implementation Mechanisms

Develop a state strategy for increasing production of Biofuels.

- Determine opportunities for appropriately scaled facilities that produce cellulose-based biofuels.
- Policy options could include
    - Ensuring that wood-based energy is given weight equal to wind and solar-based energy in renewable energy credits;
    - Changing the current Renewable Fuels Incentive to include cellulosic ethanol production specifically and give a larger incentive to it;
    - Establishing tax credit and grant program for E85[41] filling stations; and
    - Changing existing gasoline specifications in Maryland so ethanol can be blended into conventional fuel (which represents only 15% of the Maryland fuel supply; most is reformulated gasoline with E10[42]).
- 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 thermochemical or other type of process.

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[41] A blended fuel containing 85% ethanol and 15% gasoline.

[42] A blended fuel containing 10% ethanol and 90% gasoline.

- Provide financial incentives 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.
- Encourage 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—beginning in FY 2007 and lasting 10 years—offers a $0.20/gal credit for ethanol made from small grains and a $0.05/gal credit for ethanol from other agricultural sources; offers a $0.20/gal credit for bio-diesel made after 2005 from soy and a $0.05/gal credit for bio-diesel made before 2005 from any feedstock including soy. MDE reports that of the two facilities in Maryland that have shown interest in ethanol credits, only one has been permitted and has to produce within 18 months or will lose the permit. (Modification of the Act to favor production feedstocks that are not used for food and animal feed is encouraged.)
- Cellulosic feedstock and value-added by-product study (MEA)—e.g., feasibility studies.
- Renewable Fuels Task Force (created by statute)—a one-time task force with a single report as a deliverable.
- Grants for E85 refueling stations (MEA; limited funds, $50,000 total).
- Increase E85 use in state government fleets.
- US DOE construction grants for biofuels plants.
- Federal loan guarantees for biofuels production.
- Relevant 2007 Farm Bill programs.
- Requirements for State Use of Diesel—required Maryland to purchase state equipment that uses bio-diesel: 50% of state fleet diesel vehicles use at least a B5 blend beginning July 1, 2007; 50% of state off-road vehicles, and; heating and heavy equipment using at least a B5 blending beginning July 1, 2008.
- MEA provided $100,000 grants for E85 infrastructure and $100,000 for two grants for bio-diesel infrastructure.

Type(s) of GHG Reductions

CO_2: Life cycle 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 or 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 MSW. Local production of ethanol also decreases the embedded CO_2e of ethanol compared with importation from the current U.S. primary ethanol-producing regions. Current research indicates cellulose-based ethanol production provides a 72%–85% reduction in GHGs compared with gasoline, whereas an 18%–29% reduction is measured from starch-based ethanol production compared with gasoline.

The primary feedstocks for bio-diesel are vegetable oils (e.g., soy, canola, sunflower, and algal), animal fats (such as poultry) and alcohols (either methanol or ethanol). From a recent report, "Environmental, Economic and Energetic Costs and Benefits of Bio-diesel and Ethanol Biofuels" [43] bio-diesel from soybeans contains 91% of the usable energy of its petroleum equivalent and reduces life cycle GHG emissions by as much as 41%. Higher oil production potential of different feedstocks (e.g., other oil crops, algae) will likely adjust the life cycle GHG emissions further downward as they are developed as bio-diesel sources. Local production of bio-diesel also decreases the embedded CO_2e of bio-diesel compared with the importation of out-of-state supplies. In this policy, only non-food bio-diesel feedstocks will be considered.

Estimated GHG Reductions and Net Costs or Cost Savings

Ethanol

GHG-reduction potential in 2015, 2020 ($MMtCO_2e$): 0.85, 0.91.

Net cost per tCO_2e: $80.08.

This section will focus exclusively on ethanol production from cellulosic feedstocks. Maryland is a corn-deficit state, meaning that it has to import corn to meet its current food and feed needs. Because of that, there is insufficient corn to consider policy incentives to promote in-state production of corn- or starch-based ethanol.

According to studies conducted by US DOE's Argonne National Laboratory (ANL), one of the benefits of cellulosic ethanol is that it reduces GHG emissions 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.

[43] J. Hill, E. Nelson, D. Tilman, et al. 2006. Environmental, economic, and energetic costs and benefits of bio-diesel and ethanol biofuels. *Proceedings of the National Academy of Sciences* 103:11206–11210.

Data Sources: Data from the Maryland Draft Inventory & Forecast prepared for this report were the starting point for quantifying the benefits of offsetting fossil diesel and gasoline consumption with bio-diesel and ethanol produced within the state (these do not incorporate future reductions in consumption due to TLU options). Gasoline consumption estimates (under BAU) are presented in Table I-33.

Table I-33. BAU gasoline consumption

Year	Gasoline Consumption (million gal/year)
2015	2,989
2020	3,190

BAU = business as usual; gal/year = gallons per year.

The policy design calls for displacement of 3.0% of BAU gasoline consumption with cellulosic ethanol by 2015 and for maintaining displacement of 3.0% BAU consumption by 2020 as gasoline consumption increases. Ethanol has approximately 67% of the heat content of gasoline.[44] Incremental in-state ethanol production targets are presented in Table I-34.

Table I-34. Cellulosic ethanol production needed to meet policy goals

Year	BAU Gasoline Consumption (million gal/year)	Percentage To Be Displaced	Ethanol Production Needed (million gal/year)
2015	2,989	3%	135
2020	3,190	3%	144

BAU = business as usual; gal/year = gallons per year.

In-state cellulose supply was estimated from residual biomass residues. No land conversion for cultivation of fuel crops is assumed. The conversion factors in Table I-35 were used to estimate ethanol from cellulose based on US DOE and National Renewable Energy Laboratory (NREL) data.[45] US DOE and NREL assume that by 2012, the ethanol yield per ton of biomass will have improved. Estimates of biomass from crop residues, forest residues, primary and secondary mill residues, and urban wood were obtained from a DNR study.[46] This study assumes that 50% of the crop residue will be left in the fields to maintain soil or be set aside for livestock feed. Only excess residue that is sustainable will be used for conversion to fuel. Conservation Reserve Program land is also not assumed to be used for fuel production. This policy assumes that 100% of the rest of the biomass can be converted to fuel.

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

[45] US DOE. 2006 (June). Breaking the biological barriers to cellulosic ethanol: a joint research agenda. http://genomicsgtl.energy.gov/biofuels/2005workshop/2005low_intro.pdf, accessed December 28, 2008. Also, J. Ashworth, NREL, personal communication, April 6, 2007.

[46] Maryland DNR. 2006 (Mar.). The potential for biomass cofiring in Maryland. Prepared by Princeton Energy Resources International, LLC and Exeter Associates Inc. for the DNR Maryland Power Plant Research Program. Available at http://esm.versar.com/pprp/bibliography/PPES_06_02/PPES_06_02.pdf

Table I-35. Cellulose feedstock conversion factors

Year	Ethanol Yield From Cellulose (gal/ton biomass)
2008	70
2012	90
2020	100

It was assumed that it would take 7 years for production to ramp up to its maximum based on feedstock supplies. Table I-36 shows the in-state cellulosic ethanol targets based on available in-state feedstock supplies. It is assumed that 100% of biomass residue is converted to cellulosic ethanol.

Table I-36. Cellulosic ethanol annual production based on upper bound of feedstock supplies

Year	Cellulosic Ethanol (million gal)	% of BAU Consumption
2008	0	0%
2009	10	0.2%
2010	19	0.5%
2011	38	0.9%
2012	58	1.4%
2013	77	1.8%
2014	96	2.2%
2015	135	3.0%
2016	136	3.0%
2017	138	3.0%
2018	140	3.0%
2019	142	3.0%
2020	144	3.0%

BAU = business as usual; gal = gallons.

Emission factors from gasoline, starch-based ethanol and cellulosic ethanol are based on the ANL Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation (GREET) Model.[47] The life cycle CO_2e-emission factor used for gasoline is 11.74 t/1,000 gal, for starch-based ethanol is 9.60 t/1,000 gal, and for cellulosic ethanol is 3.28 t/1,000 gal.[48] The production cost differential for cellulosic versus starch-based ethanol was obtained from the NREL.[49]

[47] Ibid.

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

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

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; some of this is accounted for under the TLU policy recommendations. Overlaps have been eliminated.

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 t/1,000 gal, or 66%. This value was used along with the production in each year to estimate GHG reductions.[50] This analysis does not take into account the benefits from transitioning from gasoline to corn-based ethanol.

GHG deductions in each year were estimated by multiplying production by the incremental benefit of cellulose over corn-based ethanol.

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/gal for corn-based ethanol and $1.97/gal for cellulose-based ethanol, resulting in a differential of $0.66/gal.[51] These estimates include capital costs, thus additional incentives for capital and research and development (R&D) are not included in this analysis. The incentives are considered necessary in the near term to help commercialize technologies that produce ethanol from cellulose. The incentives should also help establish the infrastructure to deliver biomass to bio-refineries, 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/gal, compared with the $0.51/gal currently offered for ethanol production.[52] If enacted, this $0.255/gal premium could cover the additional incentives assumed to be needed by the State of Maryland. However, the federal incentives do not ensure production facilities would locate in Maryland. These federal incentives have not been factored into the cost estimates for this option.

Bio-diesel

GHG-reduction potential in 2015, 2020 (MMtCO_2e): 0.14, 0.18.

Net Cost per tCO_2e: $7.44.

Fossil diesel consumption estimates (under BAU) are presented in Table I-37.

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

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

[52] D. Morris. 2007 (Jan.). Making cellulosic ethanol happen: good and not so good public policy. Institute for Local Self-Reliance. http://www.newrules.org/agri/cellulosicethanol.pdf, accessed January 2007.

Table I-37. BAU diesel consumption

Year	Diesel Consumption (million gal/year)
2015	817
2020	941

BAU = business as usual; gal/year = gallons per year.

The policy design calls for displacement of 2% of diesel consumption by 2015 and 2.2% by 2020 with bio-diesel from non-food feedstocks, such as animal fats, yellow grease (also called sewer grease or restaurant grease), and algal oil. Bio-diesel has approximately 91% of the heat content of fossil diesel.[53] In-state bio-diesel production targets are presented in Table I-38.

Table I-38. Bio-diesel production needed to meet policy goals

Year	Bio-diesel Production Goals (million gallons)	Fraction of 2005 Consumption
2008	4	0.5%
2009	4	0.5%
2010	8	1.0%
2011	10	1.3%
2012	14	1.7%
2013	15	1.8%
2014	16	1.9%
2015	18	2.0%
2016	19	2.0%
2017	20	2.1%
2018	21	2.1%
2019	22	2.2%
2020	23	2.2%

Table I-39 presents the existing and planned facilities and capacity in Maryland.[54] Production of bio-diesel from soybean oil will not be considered under this policy, which is designed to incentivize production from non-food sources.

[53] L. Wright, B. Boundy, B. Perlack, et al. 2006 (Sept.). Biomass energy data book. Prepared by the Oak Ridge National Laboratory for the US DOE Office of Energy Efficiency and Renewable Energy, Office of Planning, Budget and Analysis. ORNL/TM-2006/571. http://cta.ornl.gov/bedb/appendix_a.shtml, accessed December 28, 2008.

[54] 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 biofuels&category_id=19, accessed January 9, 2008

Table I-39. Existing and planned bio-diesel facilities in Maryland

Facility	Status	Capacity (1,000 gal)	Feedstock	Miscellaneous
Maryland bio-diesel	In production	500	Soy, animal fat	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 8 MMgal/year

gal = gallons; MMgal.year = million gallons per year.

Table I-40 summarizes the upper limit of bio-diesel that could be produced from in-state feedstock by 2015 and 2020. Animal fats available were estimated based on the ratio of Maryland livestock and poultry slaughter and production to that of Minnesota, given that detailed amounts of grease, lard, poultry fat, and tallow available in Minnesota are known from their BioPower Evaluation Tool (BioPET), which identifies locations, types, and volumes of biomass fuels.[55] Yellow grease was projected based on industry estimates of 14 pounds of restaurant grease per capita and 7.6 pounds of grease/gal using U.S. Census projections for Maryland.[56] It was assumed that by 2020, algal bio-diesel technology would progress enough to be available to provide approximately 20% of bio-diesel production.

Table I-40. Bio-diesel potential from available feedstock

Feedstock	Bio-diesel Equivalent (1,000 gal)
Animal fats	5,791
Yellow grease 2015	11,780
Yellow grease 2020	12,329
Algal 2020—estimated at 20% of feedstock	5,000
Total 2015	**17,571**
Total 2020	**23,120**

gal = gallons.

The CO_2e emission factor for fossil diesel used in the I&F is 10.07 t/1,000 gal. The life cycle fossil diesel-emission factor is 12.3 t/1,000 gal.[57]

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

[56] 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.

[57] J. Hill, E. Nelson, D. Tilman, et al. 2006. Environmental, economic, and energetic costs and benefits of bio-diesel and ethanol biofuels. *Proceedings of the National Academy of Sciences* 103:11206–11210.

Quantification Methods:

GHG Reductions

For bio-diesel production, a new study on life cycle GHG benefits was used to estimate the CO_2e reductions for this option.[58] This study covered bio-diesel production from soybean production, which is currently the predominant feedstock source for bio-diesel production in the United States and is assumed to remain that way for the purposes of this analysis. Life cycle CO_2e reductions (via displacement of fossil diesel with soybean-derived bio-diesel) were estimated by this study to be 41%. This value is being used by the TLU TWG to estimate the benefit of the bio-diesel 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 fuel to standard imported soy.

It is assumed that technology advances will occur during the policy period allowing for commercial-scale production of algal oil to make up approximately 20% of bio-diesel production by 2020. With sufficient technology advancement, another option could be Fischer-Tropsch bio-diesel from cellulose. There is currently a similar process in place with an end product of "renewable diesel," but since it uses an esterification process, it is not considered bio-diesel.

For oil sources other than soybean oil, the benefit for substituting in-state bio-diesel for fossil diesel is estimated starting with the life cycle soybean-emission factor (7,261 tCO_2e/MMgal from the same study). As mentioned previously, the benefits of the bio-diesel component of the TLU biofuels option is based on displacement with soybean-based bio-diesel. Hence, this analysis was designed to account for only the incremental benefit of in-state feedstock (oil) production using GHG preferential feedstocks. For animal fats, algal oils, and yellow grease, the CCS assumes these have negligible embedded energy. Therefore, the incremental benefit over soy equals the soybean based the emission factor of 7,261 tCO_2e/MMgal minus transportation costs, which are assumed to average 100 miles,[59] yielding a benefit of 7,207 tCO_2e/MMgal for bio-diesel over soy-based.

The mix of feedstocks assumed was based on a respective proportion of each feedstock, using the upper bound of in-state and proximity area supply. Proximity area is defined as a 50-mile radius that may extend beyond state boundaries, as measured from potential or existing biofuels production sites.

GHG estimates for this scenario were calculated by multiplying new production of each oil feedstock by the applicable incremental benefit. Total reductions in each year were estimated by summing the incremental benefits for each oil type.

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[58] Ibid.

[59] Maximum dimension of Maryland is approximately 200 miles; 100 miles is distance from center of the state to border.

Costs

For bio-diesel, costs were estimated using information from an analysis of bio-diesel production costs from the US DOE.[60] The value of incentives needed is assumed to be $0.30/gal—the value of incentives offered in a State of Missouri incentives program.[61] In October 2004, when the $0.30 Missouri bio-diesel incentive passed, there was only one bio-diesel plant under construction in Missouri. By the end of 2007, *Bio-diesel* magazine listed eight plants in operation or under construction in the state.[62] This program offers production incentives to producers of up to 15 million gal/year. The incentive grants last for 5 years. Hence, CCS applied the incentives costs only to the first 5 years of the policy period.

CCS assumed this 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 bio-diesel produced in each year above BAU by the production incentive. This assumes all production occurs at production facilities of less than 15 million gal/year. As stated, the production incentive runs out after 5 years of production.

Key Assumptions:

All available feedstock that does not serve as a food source will be used for fuel production. *(This will be adjusted to balance with the feedstock use in AFW-6)*

Key Uncertainties

Cost competitiveness of biofuels will depend on the cost of oil. This analysis did not account for the cost of oil, which is currently $95.15/barrel of crude oil,[63] the cost of gasoline, which is currently $3.16/gal, or the cost of diesel, which is currently $3.66/gal.[64] However, if the price of oil drops substantially, alternative biofuels become less cost competitive, and any incentives outlined here may be insufficient to encourage production.

US DOE EIA has stated: "Capital costs for a first-of-a-kind cellulosic ethanol plant with a capacity of 50 million gal/year are estimated by one leading producer to be $375 million (2005 $), 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

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[60] A. Radich. 2004 (Aug.). Bio-diesel performance, cost and use. www.eia.doe.gov/oiaf/analysispaper/biodiesel/index.html, accessed January 2007.

[61] Information on the Missouri Program. Available at http://www.newrules.org/agri/mobiofuels.html - biodiesel, accessed January 2007.

[62] 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.

[63] US DOE EIA. 2008 (Feb.). Weekly petroleum status report for February 29, 2008. Available at http://www.eia.doe.gov/oil_gas/petroleum/data_publications/weekly_petroleum_status_report/wpsr.html

[64] US DOE EIA.. 2008 (Mar.). Weekly petroleum status report for March 3, 2008. Available at http://www.eia.doe.gov/oil_gas/petroleum/data_publications/weekly_petroleum_status_report/wpsr.html

cost estimates. A detailed study by the NREL in 2002 estimated total capital costs for a cellulosic ethanol plant with a capacity of 69.3 million gal/year at $200 million."[65]

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

Transitioning to large amounts of energy crop cultivation for biofuels has the potential for a negative 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 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 this technology is widely employed within the policy period and acts as a significant supplier of fuel to meet the low-carbon standard, the incremental benefits estimated here could be overstated.

Additional Benefits and Costs

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

Changes in gasoline specifications due to blending may raise vapor pressure and increase O_3. Additional information on the impacts of this type of policy is needed.

Feasibility Issues

Currently gasoline and diesel specifications are set by federal law and US EPA regulations. Any fuels used in the State of Maryland would need to conform to federal laws.

Implementation of this option requires additional R&D in cellulosic ethanol production methods, development of feedstock collection and delivery infrastructure, and 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 (crushing and bio-diesel production) must be

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

addressed for optimization and planning. Trade-offs between food and fuel crops will be an important issue. Full implementation of bio-diesel goals requires quick research advancement in algal oil harvesting.

There may be an overlap among agricultural options that seek to increase or 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.

If algal oils become commercialized, there is a possibility they could be used to meet production goals that are much higher than currently outlined in this policy.

Status of Group Approval

Approved.

Level of Group Support

Unanimous.

Barriers to Consensus

None.

AFW-8. Nutrient Trading with Carbon Benefits

Policy Description

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

Nutrient trading is a flexible and cost-effective means of achieving water quality improvements, while also providing significant carbon benefits. Nutrient trading is the transfer of credits created through reduction of nutrients, specifically nitrogen and phosphorus, from one source. For example, buyers who need to apply or release more nutrients than are currently permitted under state law could obtain credits from sellers who have produced excess nutrient credits. Opportunities exist to also promote and register any carbon reductions associated with nutrient reduction practices. This policy can 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 BMPs and advanced technologies. Advanced technologies, such as global positioning system (GPS) technology and GreenSeeker, can help with precision application of nitrogen on crops.

Many of the BMPs that would be incentivized under the nutrient trading program would also result in significant GHG reductions, such as no-till and conservation tillage, improved irrigation management, conservation buffers, grassland plantings, green infrastructure, afforestation, reforestation, and restoration of wetlands. There are a host of BMPs that would be accepted. Implementation of this program would also result in riparian buffer planting and wetlands restoration.

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

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 keep the focus on the real goal of reducing GHGs rather than just trading for economic gain.

Goals:

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

Work Group—The Agricultural Nutrient Trading Advisory Committee was formed and convened November 20, 2007. A draft policy on the non-point source and point source policy has been released. (Final Draft, March 20, 2008, “Maryland Policy for Nutrient Cap Management and

Trading in Maryland's Chesapeake Bay Watershed" will take effect in April 2008. Phase Two, non-point source trading will be released for review in May

Timing: Adopt policy by second quarter of 2008. Hold stakeholder meetings in spring and finalize in June 2008.

Parties Involved: Agricultural and urban non-point sources, municipal wastewater treatment plants, industrial and commercial dischargers, Soil Conservation Districts, MDE, and MDA.

Other: Septic system owners, other non-point sources, Chesapeake Bay Foundation (CBF), University of Maryland (UM), World Resources Institute (WRI), Maryland Association of Municipal Wastewater Agencies (MAMWA), Soil Conservation Service.

Implementation Mechanisms

A nutrient and carbon trading policy could be implemented through a watershed-based MDE general permit that authorizes trading. 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 become eligible for sale if the credits meet applicable standards under emerging state and federal laws and polices on GHGs.

Build on the policy document on point-source nutrient trading being developed by the MDE, and develop a complementary agricultural non-point source policy that includes carbon and nutrients. This can be accomplished through regulation and guidance.

Related Policies/Programs in Place

- Chesapeake Bay Program, Nutrient Trading, Fundamental Principles and Guidance, March 2001.
- MDE point-source trading document.
- US EPA, Water Quality Trading Policy, 2003.
- US EPA, Water Quality Trading Tool 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.

Type(s) of GHG Reductions

N_2O: Reductions occur when nitrogen runoff 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: CH_4 is reduced through agricultural BMPs or captured for renewable energy.

Estimated GHG Reductions and Net Costs or Cost Savings

Data Sources: See reference documents in AFW 3 regarding carbon sequestration rates from reforestation, such as the USDA FIA look-up tables, US DOE's 1605 (b) look-up table, Winrock carbon uptake model, and the Chapman–Richards growth model. See reference documents regarding carbon sequestration rates from no-till practices, such as Virginia Polytechnic Institute and State University (VT) Rainfall Simulation Research. See research analysis from the USDA Agricultural Research Service (ARS) in Fort Collins, Colorado, which included analysis on deep core soil samples for baseline data under Nitrate Leaching and Economic Analysis Package (NLEAP) and CEQUESTER models.

Quantification Methods:

A N_2O emission factor for fertilizer use was calculated by dividing the carbon equivalent emissions from fertilizer use (obtained from the Maryland I&F, which is a part of this report) by the fertilizer use for each year. Historical fertilizer use for Maryland was obtained from the MDA (1999–2000 to 2005–2006). On the basis of this historical data, it was assumed that BAU fertilizer use for the policy period would remain constant at 108,000 t/year (this was the average of all years available).[66] The target fertilizer efficiency improvements brought about through the implementation of the nutrient trading program were applied to the assumed fertilizer use over the policy period. The difference between BAU fertilizer applied and fertilizer applied under the policy is the target fertilizer reduction, shown in Table I-41.

The average CO_2e emission factor (in $MMtCO_2e$/ton of fertilizer applied) for the years 1990–2006 was used to calculate the avoided GHG emissions from the proposed increase in fertilizer efficiency resulting from the implementation of the nutrient trading program. The avoided life cycle GHG emissions (i.e., emissions associated with the production, transport, and energy consumption during application) were taken from "A Review of Greenhouse Gas Emission Factors for Fertiliser Production."[67] The estimate provided for the United States (taken from "A Synthesis of Carbon Sequestration, Carbon Emissions and Net Carbon Flux in Agriculture"[68]) was 857.5 grams of CO_2e per kilogram of nitrogen (gCO_2e/kgN)[69] or 0.778 tCO_2e per ton of nitrogen (tCO_2e/tN). This estimate was significantly lower than the estimates for European fertilizers (ranging from 5,339.9 to 7,615.9 gCO_2e/kgN). Wood and Cowie recognize that the estimate for the United States is low and suggested part of this discrepancy could be explained by the exclusion of N_2O emissions from the U.S. estimate, which are a significant component of GHG emissions.

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[66] No data for fiscal years 2002–2003.

[67] S. Wood and A. Cowie. 2004 (June). A review of greenhouse gas emission factors for fertiliser production. State Forests of New South Wales, R&D Division, Cooperative Research Centre for Greenhouse Accounting. Available at http://www.ieabioenergy-task38.org/publications/GHG_Emission_Fertilizer Production_July2004.pdf

[68] T.O. West, and G. Marland. 2001. A synthesis of carbon sequestration, carbon emissions and net carbon flux in agriculture: comparing tillage practices in the United States. *Agriculture, Ecosystems and Environment.* Volume 91, Issues 1-3, September 2002, Pages 217-232

[69] These emission factors provide an estimate of the typical life cycle GHG emissions (including resource extraction, the transport of raw materials and products, and the fertilizer production processes) per unit weight of fertilizer produced (i.e., gCO_2e/kg fertilizer).

The results of the calculations detailed in the preceding discussion are displayed in Table I-41. Note that this approach does not capture other GHG benefits associated with nutrient trading, including enhanced soil carbon sequestration, possible forest sequestration, or other land-use practices that may be incorporated under a nutrient trading program.

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 (Table I-41).[70] The program costs of nutrient trading were estimated as the sum of fertilizer savings (negative cost); costs for soil testing; costs for staff, overhead, and travel; and the costs of preparing guidance documents. Soil testing would be required for each crop field once every 4 years. The cost for each soil test was estimated to be $10, for a total cost of $683/year for soil testing (assuming $10 per 75 acre field size). Costs for two full-time equivalents of additional staff, overhead, travel, laboratory, and associated costs were estimated at $250,000/year, and preparation of guidance documents was assumed to be $75,000 in the first year.[71]

Note: The cost estimates do not include any financial benefit that may result through the generation of carbon credits.

Table I-41. Fertilizer reduction, GHG benefits, and costs of a nutrient trading program

Year	Policy Target Efficiency Improvements	Target Fertilizer Reduction (short tons N)	Avoided GHG Emissions ($MMtCO_2e$)	Annual Cost of Fertilizer Programs ($MM)	Avoided Cost of Fertilizer ($MM)	Net Cost (Savings as Negative)	Discounted Cost/Savings ($MM)
2008	2%	1,662	0.01	$1.01	–$0.639	$0.37	$0.33
2009	3%	3,324	0.02	$0.683	–$1.28	–$0.60	–$0.51
2010	5%	4,986	0.03	$0.683	–$1.92	–$1.23	–$1.02
2011	6%	6,647	0.04	$0.683	–$2.56	–$1.87	–$1.47
2012	8%	8,309	0.05	$0.683	–$3.20	–$2.51	–$1.88
2013	9%	9,971	0.07	$0.683	–$3.83	–$3.15	–$2.24
2014	11%	11,633	0.08	$0.683	–$4.47	–$3.79	–$2.57
2015	12%	13,295	0.09	$0.683	–$5.11	–$4.43	–$2.86
2016	14%	14,957	0.10	$0.683	–$5.75	–$5.07	–$3.11
2017	15%	16,618	0.11	$0.683	–$6.39	–$5.71	–$3.34
2018	17%	18,280	0.12	$0.683	–$7.03	–$6.35	–$3.53
2019	18%	19,942	0.13	$0.683	–$7.67	–$6.99	–$3.71
2020	20%	21,604	0.14	$0.683	–$8.31	–$7.63	–$3.85
Total			**1.0**				**–$29.7**

GHG = greenhouse gas; N = nitrogen; $MMtCO_2e$ = million metric tons of carbon dioxide equivalent; $MM = million dollars.

[70] April 2007 data from ERS/USDA, Available at http://www.ers.usda.gov/Data/fertilizeruse/

[71] B. Hurd. 2006. New Mexico State University, Agricultural Economics, personal communication with H. Lindquist, CCS, June.

Key Assumptions:

The quantification in this option is fully focused on fertilizers, but there are also 31 BMPs from the Chesapeake Bay Program that have not been quantified here. Those include, but are not limited to riparian buffer zone enhancement, wildlife habitat improvement, water quality improvement, erosion reduction, increased biodiversity, native vegetation enhancement, improved vegetative growth rates, and fisheries habitat improvement.

Key Uncertainties

Because of 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.

This analysis neither captures other GHG benefits associated with nutrient trading (including enhanced-soil carbon sequestration, possible forest sequestration, or other land-use practices that may be incorporated under a nutrient trading program), nor does it incorporate any financial benefits from the sale of credits or those accrued from being able to continue operation efficiently by the purchase of credits.

Other uncertainties surround baseline issues (what are the minimum standards below which credits will be generated?), timing of trading (now or in the future after implementation of certain regulatory standards?), and the duration of trade (e.g., 10 years or life of BMP?).

Additional Benefits and Costs

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

Feasibility Issues

Effective implementation and participation is dependent upon clear and appropriate guidelines and a strong outreach program that will inform potential participants of benefits and implications of participation. Broad participation will enhance the feasibility of the system's working effectively and minimizing GHG emissions, while improving soil and habitat conditions.

Status of Group Approval

Approved.

Level of Group Support

Unanimous.

Barriers to Consensus

None.

AFW-9. Waste Management Through Source Reduction (SR) and 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 landfill emissions, as well as upstream production emissions. Increase recycling and reduce waste generation in order to limit GHG emissions associated with the production of raw materials.

Reduce CH_4 emissions associated with landfilling by reducing and recycling the biodegradable fraction of waste emplaced.

For products that cannot be reused, increase recycling programs, create new recycling programs, provide incentives for recycling construction materials, develop markets for recycled materials, and increase average participation and recovery rates for all existing recycling programs to enhance and encourage up-cycling (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 suggested as policy elements, but are not included in the quantification of this option.

Policy Design

Goals: Waste stream, including diverted waste, will be reduced by 15% by 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: Start up in 2010 and ramp up to higher levels in 2012 and 2015, consistent with goals.

Parties Involved: Manufacturers, relevant trade associations, consumers' associations, all state and local agencies, consumers, and retail outlets.

Other: According to the "2006 Maryland Waste Diversion Activities Report," which provides information on the state's recycling and source reduction (SR) activities for the 2005 calendar year, Maryland achieved a recycling rate of 39.2% (including organics) and an overall diversion rate of 42.6%.[72] This recycling rate includes composted organics. The overall diversion rate includes recycling, compostable organics, and SR credits. SR credits are allocated by MDE, on the basis of approved SR programs implemented by municipalities. It is assumed these programs reduce the overall amount of waste that must be managed. Table I-42 displays diversion data in

[72] MDE. 2006. Maryland waste diversion activities report: 2006. http://www.mde.state.md.us/assets/document/recycling/2006MWDAR.pdf, accessed on December 20, 2007.

Maryland from 2001 through 2005. 2005, the most recent year for which reliable data are available, will be used as the base year, rather than 2006.

Table I-42. Data from Maryland Recycling Act Annual Reports (2001–2005)[73]

Item	2001	2002	2003	2004	2005
MRA rate	37.0%	37.0%	36.8%	35.8%	39.2%
Waste diversion rate	39.0%	39.5%	39.6%	38.8%	42.6%
SR credit	2.0%	2.5%	2.8%	3.0%	3.4%
Compostables (tons)	617,390	645,230	892,250	853,094	944,358
Glass (tons)	47,764	55,481	64,894	71,558	57,889
Metals (tons)	220,631	251,703	271,646	302,904	535,195
Paper (tons)	948,513	909,447	821,652	861,927	840,644
Plastic (tons)	23,149	35,930	24,483	30,663	36,858
Miscellaneous (tons)	547,586	558,050	518,599	561,829	518,935
Total MRA diversion, including organics (tons)	2,405,033	2,455,841	2,593,524	2,681,975	2,933,879
Recycling, excluding organics (tons)	1,787,643	1,810,611	1,701,274	1,828,881	1,989,521
Total MRA waste disposed in landfills and incinerators* (tons)	4,095,056	4,181,567	4,454,096	4,809,575	4,550,506
Total MRA waste, including recycling (tons)*	6,500,089	6,637,408	7,047,620	7,491,550	7,484,385
Total source reduction (tons)*	132,655	170,190	203,018	231,697	263,426
Total generation, including recycling, composting, and source reduction (tons)*	6,632,744	6,807,598	7,250,637	7,723,248	7,747,811
% Change*		**2.6%**	**6.5%**	**6.5%**	**0.3%**
Annual generation change*	**3.4%**				
Average annual recycling rate*	**37.2%**				

MRA = Maryland Recycling Act; SR = source reduction.

*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 US EPA definition of 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 was 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

[73] MDE. Maryland waste diversion activities Reports: 2002–2006. Reporting data from 2001 to 2005. Available at http://www.mde.state.md.us/Land/land_publications/index.asp

of Columbia.[74] Considering the net exports of landfill MSW in Maryland, the baseline rate for recycling in Maryland was 31.2% (including organics), lower than the rate reported by the 2005 Maryland Recycling Act Report.[75] As Table I-43 shows, the BAU composting level is projected by assuming that 32% of total diversion is composted.[76] For this analysis, all waste generated in Maryland will be included, but not the waste imported from elsewhere.

Table I-43. BAU waste management projection for Maryland

Item	2005	2010	2012	2015	2020
Total Maryland waste generation, including net exports (tons)	9,242,389	10,904,236	11,649,832	12,864,895	15,178,095
MSW managed in-state, 3.4%/year growth from 2001–2005 (tons)	7,747,811	9,140,922	9,765,948	10,784,525	12,723,659
Net MSW exports (tons)	1,494,578	1,763,314	1,883,883	2,080,370	2,454,435
Maryland 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)	1.7	1.9	2.0	2.1	2.4
MSW diverted, including recycling and organics, 39.2% MSW managed in state; 2005 baseline (tons)	2,933,879	3,583,242	3,828,252	4,227,534	4,987,674
MSW composting, 32% of MSW recycled (tons)	938,841	1,146,637	1,225,041	1,352,811	1,596,056
MSW disposed, in-state landfills only (tons)	3,169,045	3,617,031	3,864,352	4,267,399	5,034,708
MSW disposed in all landfills (tons)	4,949,634	5,717,783	6,108,746	6,745,881	7,958,838
WTE (incinerators), 18% of waste generated (tons)	1,358,876	1,603,212	1,712,834	1,891,480	2,231,582

BAU = business as usual; MSW = municipal solid waste; I&F = Inventory and Forecast; WTE = waste-to-energy.

Implementation Mechanisms

- Require or encourage all government agencies to preferentially purchase goods made from reused and recycled materials and goods from manufacturers who take "cradle-to-cradle" responsibility for their products.
- Identify incentives that encourage the reuse and recycling of materials and products, and discourage single-use waste.
- 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.

[74] MDE. 2006 (Sept.). Annual report: solid waste management in Maryland—calendar year 2005. http://www.mde.state.md.us/assets/document/SW_Managed_in_MD_Report_CY_2005.pdf, accessed on December 20, 2007,

[75] 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).

[76] 32% = 944,358 tons composted/2,933,879 tons diverted.

- Identify and phase out any subsidies that discourage waste reduction, reuse of components, or improved quality and longevity of products.
- Work with a variety of public education and outreach programs to ensure information about recycling, waste reduction, and appropriate reuse is available and appropriately disseminated.
- Divert compostables from landfills. Recently, an area of focus in the solid waste industry has been to increase recycling of organic wastes (e.g., lawn and garden waste, food waste, wood, and paper) using different conversion technologies, including composting, anaerobic digestion, or hybrids of these technologies, which tend to be problematic and can have negative impacts not only in smell, but also in groundwater pollution. Diverting compostables from landfills offers a tremendous opportunity for reducing GHG emissions due to the higher global warming potential of CH_4. Therefore, these types of programs should be included in the overall plan. However, care will be given to making sure the composting programs of organic waste do not create additional problems, such as foul odors, groundwater pollution, or increasing rodent populations.
- The European Union has the Waste Electronic and Electrical Equipment (WEEE) Directive. Manufacturers of all electronic and electrical equipment sold in Europe are required to take back all products when they are no longer useful or desired by the purchaser. This encourages the use of interchangeable, reusable parts; elimination of toxins and heavy metals; and maximum recycling, which significantly reduces waste. Although this type of program would be challenging for Maryland to implement independently, it should be considered. At a minimum, Maryland should recommend to our national policy makers that similar legislation be passed at the national level.
- Implement "Resource Management (RM) Contracting."[77] RM contracting rationalizes incentives such that the contracting waste hauler receives revenue from sorting and selling recyclable materials. This could include the cost transfer of tipping fees to the contracting waste hauler to provide a disincentive for the disposal of waste to a landfill or incinerator. This provides a financial incentive to the contracting waste hauler to maintain effective collection programs and to ensure appropriate sorting and recycling.

Related Policies/Programs in Place

There are no cradle-to-cradle programs in place, but MDE does have an aggressive e-cycling program to deal with electronic waste.

Type(s) of GHG Reductions

CH_4: CH_4 reductions because of reduced volumes in landfills. Diverting biodegradable wastes from landfills will result in a decrease in CH_4 gas releases from landfills.

CO_2: Upstream energy use reductions. The energy and GHG intensity of manufacturing a product is generally less when using recycled feedstocks than when using virgin feedstocks. The energy saved is substantial and resource reduction is gained by using less packaging, for example, and by eliminating single-use containers.

[77] For more information on RM contracting, see http://www.epa.gov/wastewise/wrr/rm.htm and http://www.epa.gov/wastewise/pubs/rr_rm.pdf

Estimated GHG Reductions and Net Costs or Cost Savings

GHG-Reduction Potential in 2015, 2020 ($MMtCO_2e$): 17.0, 29.2.

Net Cost per tCO_2e: –$6.

Data Sources: Baseline recycling and waste generation estimates and projections were developed from annual reports on the waste diversion activity and solid waste management in Maryland.[78] The breakdown of the waste disposed in Maryland by type was derived from U.S.-level data provided in the US EPA's 2005 Waste Characteristics Report.[79] The breakdown of baseline-recycled waste in Maryland was derived from the 2006 Maryland Recycling Act (MRA) Annual Report[80] and the US EPA's 2005 Waste Characteristics Report. The GHG emission reductions were modeled using US EPA's WAste Reduction Model (WARM).[81]

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 by CCS in previous quantifications of similar options in other state action plans. Maryland-specific information is from the 2006 MRA Report[82] and a case study from Montgomery County, "Composting/Grasscycling Program Summary." [83]

[78] MDE. 2006. Maryland waste diversion activities report: 2006. http://www.mde.state.md.us/assets/document/recycling/2006MWDAR.pdf, accessed on December 20, 2007. Also MDE. 2006 (Sept.). Annual report: solid waste management in Maryland—calendar year 2005. http://www.mde.state.md.us/assets/document/SW_Managed_in_MD_Report_CY_2005.pdf , accessed on December 20, 2007.

[79] US EPA Office of Solid Waste. 2006 (Oct.). Municipal solid waste in the United States, 2005 facts and figures. EPA530-R-06-011. http://www.epa.gov/garbage/pubs/mswchar05.pdf, accessed on December 30, 2007.

[80] MDE. 2006. Maryland waste diversion activities report: 2006. http://www.mde.state.md.us/assets/document/recycling/2006MWDAR.pdf, accessed on December 20, 2007.

[81] Version 8, May 2006. Available at 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 as a Web-based calculator and as a Microsoft Excel spreadsheet. WARM calculates and totals GHG emissions of baseline and alternative waste management practices—SR, recycling, combustion, composting, and landfilling. The model calculates emissions in metric tons of carbon equivalent (MtCe), metric tons of carbon dioxide equivalent ($MtCO_2e$), and energy units (MBtu) 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. Available at http://epa.gov/climatechange/wycd/waste/SWMGHGreport.html

[82] MDE. 2006 (Sept.). Annual report: solid waste management in Maryland—calendar year 2005. http://www.mde.state.md.us/assets/document/SW_Managed_in_MD_Report_CY_2005.pdf, accessed on December 20, 2007.

[83] DEP. Composting/grasscycling program summary. Prepared by R. Kashmanian, US EPA, in 1996 for Montgomery County, Maryland. http://www.montgomerycountymd.gov/deptmpl.asp?url=/content/dep/composting/summary.asp, accessed on January 11, 2008.

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.[84] Since the information regarding the net export of waste comes from a different document than the MRA recycling rate, the recycling rate of 39.2% will be applied to MSW managed in-state for consistency. Based on the total diversion rate (42.6% in 2005), the total estimated waste generated—including tons of source material reduced—is 7,747,881 tons (shown in Table I-43 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%. This historic average is used to project future baseline generation.

Organic composting is assumed to consist of food and yard waste collected curbside and processed at a central composting facility. While this is a part of the MRA recycling figure, yard trimmings and food waste are treated as compostables by US EPA's WARM. Therefore, this analysis will separate organic composting from recycling. The cost analysis for organic composting will differ for that of recycling as well.

SR is the process of reducing the amount of refuse that enters the waste stream. For this analysis, the only items that are "source reduced" are those for which SR is an accepted input for WARM (see Table I-42 for accepted inputs).

The analysis of this policy option 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 SR 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 BAU—projections for waste generation, recycling, landfilling, exports, imports, and incineration are given in Table I-43.

Table I-44 shows the projected waste generation and diversion, including recycling and SR, through 2020. These projections are formulated by applying the goals set forth by the TWG to the baseline projections from Table I-43. Table I-45 displays the incremental changes in waste generation and diversion as a result of the policy goals, that is, the difference between Tables I-43 and I-44.

[84] Waste captured by the MRA diversion rate is determined on a county level. However, the MRA excludes scrap metal, land-clearing 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 MSW. This calculation is performed utilizing the following equation: Waste Disposed=MRA Recycling * (1–Recycling %)/(Recycling %)

Table I-44. 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%
Total Maryland waste generation, including net exports (tons)	9,242,389	10,359,024	9,902,357	9,648,671	9,865,762
MSW generation per capita (tons/person)	1.7	1.8	1.7	1.6	1.6
MSW source reduced (tons)	—	545,212	1,747,475	3,216,224	5,312,333
MSW diverted (tons)	2,933,879	3,702,683	4,211,077	5,073,041	6,483,977
MSW disposed, in-state landfills only (tons)	3,455,056	3,503,273	2,876,482	2,120,698	1,256,376
Net MSW exports, to out-of-state landfills (tons)	1,494,578	1,675,148	1,601,301	1,560,278	1,595,383
Total MSW landfill disposal (tons)	4,949,634	5,178,421	4,477,783	3,680,975	2,851,759
WTE, 29.7% of waste disposed (tons)	1,358,876	1,477,920	1,213,497	894,655	530,025

MSW = municipal solid waste; WTE = waste-to-energy.

Table I-45. Tons of incremental diversion under policy goals

Item	2005	2010	2012	2015	2020
MSW recycled, including organic composting	—	119,441	382,825	845,507	1,496,302
MSW recycled, excluding organic composting	—	86,834	278,313	614,681	1,087,808
MSW composted	—	32,608	104,512	230,826	408,495
MSW source reduced	—	545,212	1,747,475	3,216,224	5,312,333
MSW landfilled	—	–539,362	–1,630,963	–3,064,905	–5,107,079
MSW incinerated (WTE)	—	–125,292	–499,337	–996,825	–1,701,557
Incremental diversion (tons)	—	**664,653**	**2,130,300**	**4,061,731**	**6,808,635**
Total diversion (%)	**31.7%**	**39.0%**	**51.1%**	**64.4%**	**77.7%**
Incremental diversion (%)	**—**	**6.1%**	**18.3%**	**31.6%**	**44.9%**

MSW = municipal solid waste; WTE = waste-to-energy.

The waste generated in Maryland is broken down into six main 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 I-46 shows the composition of waste generated in Maryland.

Of the six categories displayed in the breakout in Table I-46, 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 it is assumed that "other" is represented by the WARM category of "mixed recyclables." Table I-47 shows the breakdown of waste disposed in landfills or incinerator facilities 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.[85]

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 broken out by multiplying the total quantity of waste landfilled for each category by the share of disposal for each waste type. For example, the baseline landfill disposal projection for 2020 is 7,958,838 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 21.0% (Table I-47). The result is the projected amount of corrugated cardboard landfilled in 2020 under the baseline scenario (571,604 tons). The process for estimating the characterization of waste incinerated is identical to the methodology used to estimate the characterization of waste landfilled (Table I-47).

[85] MDE. 2006 (Sept.). Annual report: solid waste management in Maryland—calendar year 2005. http://www.mde.state.md.us/assets/document/SW_Managed_in_MD_Report_CY_2005.pdf, accessed on December 20, 2007.

Table I-46. Waste generation characteristics[86]

Category	Baseline Composition (BAU)
Paper	34.2%
Organics	25.0%
Mixed plastic	11.8%
Metals	7.6%
Glass	5.5%
Other (assumed mixed recyclables)	15.9%

BAU = business as usual.

Table I-47. Characterization of waste disposed (landfill and waste-to-energy [WTE])[87]

Waste Type	BAU
% of discarded paper	
Corrugated cardboard	21.0%
Magazines/third-class mail	12.6%
Newspaper	3.2%
Office paper	5.9%
Phonebooks	1.3%
Textbooks	2.0%
Other (assumed mixed paper, broad)	54.0%
% of discarded organics	
Food waste	70.0%
Yard trimmings	30.0%
% of discarded plastics	
HDPE	24.9%
LDPE	29.0%
PET	9.7%
Other (assumed mixed plastics)	36.4%
% of discarded metals	
Aluminum cans	58.2%
Steel cans	41.8%

BAU = business as usual; % = percent; HDPE = high-density polyethylene; LDPE = low-density polyethylene; PET = polyethylene terephthalate.

The baseline composition of recycled waste is derived from the data presented in the MRA report on diversion activities over the 2005 calendar year (Table I-48).[88] The further

[86] US EPA, Office of Solid Waste. 2006 (Oct.). Municipal solid waste in the United States, 2005 facts and figures. EPA530-R-06-011. http://www.epa.gov/garbage/pubs/mswchar05.pdf, accessed on December 30, 2007.

[87] Ibid.

characterization of waste recycled in Maryland is estimated on the basis of national data from the US EPA's 2005 Waste Characteristics report (Table I-49).[89]

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 down 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 52.7%. The result is the projected amount of corrugated cardboard recycled in 2020 under the baseline scenario (762,226 tons).

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[88] MDE. 2006 (Sept.). Annual report: solid waste management in Maryland—calendar year 2005. http://www.mde.state.md.us/assets/document/SW_Managed_in_MD_Report_CY_2005.pdf, accessed on December 20, 2007.

[89] US EPA, Office of Solid Waste. 2006 (Oct.). Municipal solid waste in the United States, 2005 facts and figures. EPA530-R-06-011. http://www.epa.gov/garbage/pubs/mswchar05.pdf, accessed on December 30, 2007.

Table I-48. Recycled waste characteristics

Category	Baseline Recycling (BAU)
Paper	29.0%
Organics	32.0%
Mixed plastic	1.0%
Metals	18.0%
Glass	2.0%
Other (assumed mixed recyclables)	18.0%

BAU = business as usual.

Table I-49. Baseline and policy recycling characterization

Waste Type	BAU	2015 Policy	2020 Policy
% of discarded paper			
Corrugated cardboard	52.7%	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	2.7%	66.1%	86.2%
% of discarded organics			
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%

BAU = business as usual; % = percent; HDPE = high-density polyethylene; LDPE = low-density polyethylene; PET = polyethylene terephthalate.

The limitations of WARM preclude one from applying the 35% reduction in generation by 2020 (henceforth, SR) across all waste types—WARM does not accept SR as an input for mixed paper, food waste, yard trimmings, mixed plastics, or mixed recyclables. Therefore, it is necessary to achieve the SR goal by assuming that only materials where SR is an acceptable WARM input are source reduced. The application of the SR goal to the remaining waste types results in a negative amount of waste landfilled or incinerated for many categories, which is not a plausible result. Thus, additional "recycling" quantities are allocated to the "mixed" waste types to ensure the total quantity of diversion instructed by the policy option goal is entered into the model. The composition of waste that is source reduced is shown in Table I-50.

Table I-50. Composition of waste "source reduced"

Waste Type	% of Total SR
Glass	10.7%
HDPE	5.2%
LDPE	5.8%
PET	2.2%
Corrugated cardboard	24.3%
Magazines/third-class mail	8.9%
Newspaper	7.8%
Office paper	5.6%
Phonebooks	1.0%
Textbooks	1.4%
Aluminum cans	11.9%
Steel cans	15.3%

SR = source reduction; HDPE = high-density polyethylene; LDPE = low-density polyethylene; PET = polyethylene terephthalate.

The waste generated for each waste type under the baseline scenario is estimated 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 sum the calculated baseline waste landfilled, incinerated, and recycled (methods for these calculations are listed above).

The tons of source reduced for each waste type are calculated for each waste type, where SR is a valid WARM input. The calculation uses a multiplier (see Table I-51) derived from the total quantity of SR divided by the total waste generation. This multiplier is used to estimate the SR for each waste type, allocating the quantity of waste source reduced proportionally among recycling, landfilling, and incineration.

Table I-51. Source reduction multiplier

Source Reduction Multiplier	2010	2012	2015	2020
SR as a percentage of WARM SR categories' BAU generation	12.3%	37.0%	61.7%	86.3%

WARM = WAste Reduction Model; SR = source reduction; BAU = business as usual.

The total tons of waste diverted for each category under the policy scenario are calculated using a diversion multiplier (see Table I-52), which is derived in the same manner as the source reduction multiplier. This multiplier is applied to the waste remaining after SR. The diversion is allocated proportionally to waste that would have been headed to landfills and incinerators.

Table I-52. Diversion multiplier

Diversion Multiplier	2010	2012	2015	2020
Incremental recycling as a percentage of all categories' BAU generation	1.1%	3.3%	6.6%	9.9%

BAU = business as usual.

The BAU and policy scenario waste management projections for each waste type are entered into WARM for the years 2015 and 2020. GHG reductions are assumed to increase linearly from 2010 to 2015 and from 2015 to 2020. WARM is a static model, so only one year's inputs may be entered per run. Tables AFW-53 and AFW-54 show the WARM inputs for the 2020 baseline (BAU) and policy scenarios, as they would appear in the WARM workbook.

Table I-53. 2020 baseline WARM inputs

Material	Tons Generated	Tons Recycled	Tons Landfilled	Tons Combusted	Tons Composted
Aluminum cans	733,544	282,801	352,035	98,707	N/A
Steel cans	938,710	614,980	252,836	70,893	N/A
Copper wire					N/A
Glass	660,227	99,753	437,736	122,737	N/A
HDPE	319,665	20,250	233,847	65,568	N/A
LDPE	354,103	5,387	272,351	76,365	N/A
PET	137,688	21,048	91,097	25,543	N/A
Corrugated cardboard	1,494,142	762,266	571,604	160,272	N/A
Magazines/third-class mail	544,715	105,589	342,962	96,163	N/A
Newspaper	480,362	368,839	87,102	24,422	N/A
Office paper	347,372	141,750	160,593	45,029	N/A
Phonebooks	59,771	14,464	35,385	9,922	N/A
Textbooks	84,167	14,464	54,438	15,264	N/A
Dimensional lumber					N/A
Medium-density fiberboard					N/A
Food scraps	2,900,563	N/A	1,392,797	390,527	1,117,239
Yard trimmings	1,243,098	N/A	596,913	167,369	478,817
Grass		N/A			
Leaves		N/A			
Branches		N/A			
Mixed paper (general)	1,921,020	39,053	1,469,838	412,129	N/A
Mixed paper (primarily residential)					N/A
Mixed paper (primarily from offices)					N/A
Mixed metals					N/A
Mixed plastics	440,891	3,192	341,848	95,851	N/A
Mixed recyclables	2,518,058	897,781	1,265,455	354,822	N/A
Mixed organics		N/A			
Mixed MSW		N/A			N/A
Carpet					N/A
Personal computers					N/A
Clay bricks		N/A		N/A	N/A
Aggregate				N/A	N/A
Fly ash				N/A	N/A

N/A = not applicable; HDPE = high-density polyethylene; LDPE = low-density polyethylene; PET = polyethylene terephthalate; MSW = municipal solid waste.

Table I-54. 2020 policy WARM inputs

Material	Baseline Generation	Tons Source Reduced	Tons Recycled	Tons Landfilled	Tons Combusted	Tons Composted
Aluminum cans	733,544	633,171	42,511	45,190	12,671	N/A
Steel cans	938,710	810,264	92,445	28,117	7,884	N/A
Copper wire						N/A
Glass	660,227	569,886	14,995	58,846	16,500	N/A
HDPE	319,665	275,924	3,044	31,784	8,912	N/A
LDPE	354,103	305,650	810	37,210	10,433	N/A
PET	137,688	118,847	3,164	12,243	3,433	N/A
Corrugated cardboard	1,494,142	1,289,695	114,585	70,183	19,679	N/A
Magazines/third-class mail	544,715	470,180	15,872	45,816	12,846	N/A
Newspaper	480,362	414,633	55,445	8,032	2,252	N/A
Office paper	347,372	299,840	21,308	20,481	5,743	N/A
Phonebooks	59,771	51,592	2,174	4,689	1,315	N/A
Textbooks	84,167	72,650	2,174	7,297	2,046	N/A
Dimensional lumber						N/A
Medium-density fiberboard						N/A
Food scraps	2,900,563	N/A	N/A	1,169,469	327,908	1,403,185
Yard trimmings	1,243,098	N/A	N/A	501,201	140,532	601,365
Grass		N/A	N/A			
Leaves		N/A	N/A			
Branches		N/A	N/A			
Mixed paper, broad	1,921,020	N/A	1,721,034	156,192	43,795	N/A
Mixed paper, residential		N/A				N/A
Mixed paper, office		N/A				N/A
Mixed metals		N/A				N/A
Mixed plastics	440,891	N/A	166,319	214,444	60,128	N/A
Mixed recyclables	2,518,058	N/A	2,223,546	230,018	64,495	N/A
Mixed organics		N/A	N/A			
Mixed MSW		N/A	N/A			N/A
Carpet						N/A
Personal computers						N/A
Clay bricks			N/A		N/A	N/A
Aggregate		N/A			N/A	N/A
Fly ash		N/A			N/A	N/A

WARM = WAste Reduction Model; N/A = not applicable; HDPE = high-density polyethylene; LDPE = low-density polyethylene; PET = polyethylene terephthalate.

WARM runs yielded the GHG benefits reported at the beginning of this section: 17.0 $MMtCO_2e$ reduced in 2015 and 29.2 $MMtCO_2e$ reduced in 2020. To estimate the cumulative emissions through 2020, the emission reductions are assumed to increase linearly from 0 in 2009 to 17.0 $MMtCO_2e$ in 2015 and from 17.0 $MMtCO_2e$ in 2015 to 29.2 $MMtCO_2e$ in 2020. The results are shown in Table I-55.

Table I-55. Overall policy results, GHG reductions

Year	Avoided Emissions ($MMtCO_2e$)	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
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
Total	**186.80**	**42,134,683**	**33,678,812**	**8,455,871**	**–32,650,768**	**–9,483,916**	**–5,446,169**

GHG = greenhouse gas; $MMtCO_2e$ = million metric tons of carbon dioxide equivalent; WTE = waste-to-energy.

Cost-Effectiveness

Source Reduction. A net cost for the state to implement SR programs of $1 per capita is assumed.[90] 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 this analysis, it was assumed the waste would have been landfilled. Therefore, the landfill-tipping fee (estimated at $52/ton) is avoided.[91] CCS assumed the cost for collecting the waste would not be avoided, since weekly collection of the remaining household and business waste would still be needed. Table I-56 provides a summary of the costs estimated for the SR element of this policy. Cumulative reductions (estimated from WARM results) are about 164 $MMtCO_2e$ through the policy period. A cost-effectiveness of –$7 tCO_2e was calculated along with a NPV of –$1,174 million.

[90] Not a Maryland-specific estimate. The SR program cost is a preliminary estimate consistent with costs assumed in similar options considered by CCS projects in Washington and Colorado.

[91] MDE. 2006 (Sept.). Annual report: solid waste management in Maryland—calendar year 2005. http://www.mde.state.md.us/assets/document/SW_Managed_in_MD_Report_CY_2005.pdf, accessed on December 20, 2007.

Table I-56. 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 ($MMtCO_2e$)	Cost-Effectiveness ($/$tCO_2e$)
2009	—	$0.00	$0.00	$0.00	$0.00	0.00	
2010	545,212	$28.35	$5.91	–$22.44	–$21.37	2.55	
2011	1,127,087	$58.61	$5.95	–$52.66	–$47.76	5.10	
2012	1,747,475	$90.87	$5.99	–$84.88	–$73.32	7.65	
2013	2,207,615	$114.80	$6.03	–$108.77	–$89.48	10.20	
2014	2,696,722	$140.23	$6.07	–$134.16	–$105.12	12.75	
2015	3,216,224	$167.24	$6.11	–$161.13	–$120.24	15.30	
2016	3,590,312	$186.70	$6.16	–$180.54	–$128.31	17.62	
2017	3,985,921	$207.27	$6.20	–$201.07	–$136.09	19.95	
2018	4,404,073	$229.01	$6.24	–$222.77	–$143.60	22.27	
2019	4,845,839	$251.98	$6.28	–$245.70	–$150.84	24.59	
2020	5,312,333	$276.24	$6.33	–$269.91	–$157.81	26.24	
Total				**–$1,684.03**	**–$1,173.95**	**164.2**	**–$7.15**

2006$MM = million 2006 dollars; $MMtCO_2e$ = million metric tons of carbon dioxide equivalent; $/$tCO_2e$ = dollars per metric ton of carbon dioxide equivalent.

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.[92] Dividing this number by the incremental recycling per capita in 2020[93] times the average household size of 2.61 people[94] yields the maximum collection cost of $51/ton. The capital cost of additional recycling facilities in Maryland is $255 million.[95] Annualized over the 10-year policy period at 5% interest, the capital cost is $16.5 million/year. The avoided cost for landfill tipping is $52/ton.[96] CCS also factored in the commodity value of recycled materials at $35/ton.[97] Table I-57 provides the

[92] Not a Maryland-specific estimate. (T. Brownell. 2007. Eureka Recycling, personal communication with S. Roe, CCS, 17 December 17.) This value compares favorably with data provided to the AFW TWG (T. Troolin, St. Louis County) on recycling costs incurred by Minnesota counties.

[93] Population projection for 2020 from the Maryland I&F.

[94] U.S. Census Bureau. State & county QuickFacts—Maryland. http://quickfacts.census.gov/qfd/states/24000.html, accessed on January 11, 2008.

[95] Not a Maryland-specific estimate. Based upon ratio of capital cost per household used in Vermont analysis. Vermont capital cost a result of personal communication with P. Calabrese. (P. Calabrese. 2007. Cassella Waste Management, personal communication with S. Roe, CCS, 5 June.)

[96] MDE. 2006 (Sept.). Annual report: solid waste management in Maryland—calendar year 2005. http://www.mde.state.md.us/assets/document/SW_Managed_in_MD_Report_CY_2005.pdf, accessed on December 20, 2007.

[97] Not a Maryland-specific estimate. (T. Brownell. 2007. Eureka Recycling, personal communication with S. Roe, CCS, 17 December.) This value compares with a wide range of weighted commodity value provided by T. Troolin,

results of the cost analysis. The analysis assumes costs begin to be incurred in 2010. The estimated cost savings result in an NPV of –$35 million. Cumulative reductions are almost 14 $MMtCO_2e$, and the estimated cost-effectiveness is –$2.5/$tCO_2e$.

Table I-57. 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-Effective-ness ($/t)
2009	—	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	0.00	
2010	86,834	$4.22	$16.51	$3.04	$4.52	$13.17	$12.55	0.22	
2011	179,506	$8.72	$16.51	$6.28	$9.33	$9.62	$8.72	0.44	
2012	278,313	$13.53	$16.51	$9.74	$14.47	$5.82	$5.03	0.66	
2013	383,561	$18.64	$16.51	$13.42	$19.95	$1.78	$1.46	0.88	
2014	495,572	$24.09	$16.51	$17.35	$25.77	–$2.52	–$1.98	1.10	
2015	614,681	$29.87	$16.51	$21.51	$31.96	–$7.09	–$5.29	1.32	
2016	698,883	$33.97	$16.51	$24.46	$36.34	–$10.33	–$7.34	1.51	
2017	788,053	$38.30	$16.51	$27.58	$40.98	–$13.75	–$9.31	1.71	
2018	882,429	$42.89	$16.51	$30.89	$45.89	–$17.38	–$11.20	1.90	
2019	982,261	$47.74	$16.51	$34.38	$51.08	–$21.21	–$13.02	2.09	
2020	1,087,808	$52.87	$16.51	$38.07	$56.57	–$25.26	–$14.77	2.20	
Total						**–$67.15**	**–$35.15**	**14.00**	**–$2.50**

2006$MM = million 2006 dollars; $MM = million dollars; MMt = million metric tons; $/t = dollars per metric ton.

Composting. Composting is included in the total recycling volume by the MRA Report. However, as the WARM model considers the sole form of diversion for yard trimmings and food waste to be composting, it is assumed that the tons of these "recycled" items are composted. 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, and the avoided tipping fees for landfilling. Information on the capital and operating costs of composting facilities was received from Cassella Waste Management during the seventh analysis of a similar option in Vermont.[98] These data are summarized in Table I-58.

St. Louis County. The weighted commodity value range is estimated to be about $25–$70/ton, with the higher end representing current values. CCS selected the value of $35/ton as a conservative estimate for this analysis.

[98] Not a Maryland-specific estimate. (P. Calabrese. 2007. Cassella Waste Management, personal communication with S. Roe, CCS, 5 June.)

Table I-58. Cost information for composting facilities

Annual Volume (tons)	Capital Cost (2007 $M)	Operating Cost ($/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

2007$M = thousand 2007 dollars; $/ton = dollars per ton.

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 I-58. The composting volumes in 2015 and 2020 shown in Table I-59 suggest the need for four large composting operations by 2015 and another four 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,[99] an additional 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,[100] and a compost value of $10/ton.[101]

Table I-59 presents the results of the cost analysis for composting. GHG reductions were assumed not to begin until 2010, and the cumulative reductions estimated were 0.50 MMtCO_2e. An NPV of $91 million was estimated along with a cost-effectiveness of $183/t.

[99] MDE. 2006 (Sept.). Annual report: solid waste management in Maryland—calendar year 2005. http://www.mde.state.md.us/assets/document/SW_Managed_in_MD_Report_CY_2005.pdf, accessed on December 20, 2007.

[100] DEP. Composting/grasscycling program summary. Prepared by R. Kashmanian, US EPA, in 1996 for Montgomery County, Maryland. http://www.montgomerycountymd.gov/deptmpl.asp?url=/content/dep/composting/summary.asp, accessed on January 11, 2008.

NOTE: Figures originally presented in 1995$, and were converted to 2006$ by using the conversion tool at http://www.westegg.com/inflation/.

[101] Ibid.

The overall cost analysis (Table I-60) yields an NPV of –$1,117 and a cost-effectiveness of –$6, based on the cumulative emission reductions of 183 $MMtCO_2e$.

Table I-60. 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$MM)	Cost-Effectiveness ($/tCO2e)
2009	$0.00	$0.00	$0.00	$0.00	$0.00	
2010	$13.17	$2.07	–$22.44	–$7.20	–$6.86	
2011	$9.62	$3.45	–$52.66	–$39.60	–$35.92	
2012	$5.82	$5.69	–$84.88	–$73.37	–$63.38	
2013	$1.78	$8.03	–$108.77	–$98.95	–$81.41	
2014	–$2.52	$9.70	–$134.16	–$126.97	–$99.49	
2015	–$7.09	$12.25	–$161.13	–$155.97	–$116.39	
2016	–$10.33	$14.28	–$180.54	–$176.59	–$125.50	
2017	–$13.75	$16.38	–$201.07	–$198.44	–$134.31	
2018	–$17.38	$17.79	–$222.77	–$222.36	–$143.33	
2019	–$21.21	$20.05	–$245.70	–$246.86	–$151.55	
2020	–$25.26	$22.39	–$269.91	–$272.78	–$159.49	
Total					**–$1,117.63**	**–$6.11**

$MM = million dollars; 2006$MM = million 2006 dollars; $/tCO2e = dollars per metric ton of carbon dioxide equivalent.

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 estimated GHG reductions would be lower. No additional expansion of 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 WARM in estimating life cycle GHG benefits and the use of the stated assumptions regarding costs for increased SR, recycling, and organics recovery (e.g., composting) programs.

Another important assumption is that under BAU, the waste directed to landfilling would include CH_4 recovery (75% collection efficiency) and utilization. The need for this assumption is partly based on limitations of WARM (which doesn't allow for management of landfilled waste into controlled and uncontrolled landfills), and is 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 savings that would be achieved through avoiding the need for additional waste-to-energy (WTE) plants.

In some cases, Maryland-specific information was not available, and alternative data was used as a default:

- The breakdown of the waste disposed in Maryland by type was derived from U.S.-level data provided in the US EPA's 2005 Waste Characteristics Report.
- 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 alternate information.
  - A net cost for the state to implement SR programs of $1 per capita is assumed.[102]
  - The additional cost to separate curbside collection of recyclables was assumed to be $2.50/household/month, or $30/household/year.[103]
  - The capital cost of additional recycling facilities in Maryland was assumed to be $255 million.[104]
  - Commodity value of recycled materials was assumed to be $35/ton.[105]
  - 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.[106]

Key Uncertainties

Biomass derived from landfilled waste may be diverted for use in electricity, heat, and steam generation facilities (see AFW-6). Such a diversion would not reduce total carbon emissions, because the carbon in the waste biomass is biogenic. However, more of this biogenic carbon is emitted as CH_4 in landfill emissions than as biomass combustion emissions. Such a diversion would likely reduce the overall GHG emissions from landfills in Maryland.

There are some actions that are difficult to quantify and mitigate. Examples include illegal disposal of hydrofluorocarbons and uninformed disposal of hazardous wastes, such as paints,

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[102] The SR program cost is a preliminary estimate consistent with costs assumed in similar options considered by CCS projects in Washington and Colorado.

[103] T. Brownell. 2007. Eureka Recycling, personal communication with S. Roe, CCS, 17 December.

[104] Based upon ratio of capital cost per household used in Vermont analysis. Vermont capital cost a result of personal communication with P. Calabrese. (P. Calabrese. 2007. Cassella Waste Management, personal communication with S. Roe, CCS, 5 June.)

[105] T. Brownell. 2007. Eureka Recycling, personal communication with S. Roe, CCS, 17 December. This value compares with 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–$70/ton, with the higher end representing current values. CCS selected the value of $35/ton as a conservative estimate for this analysis.

[106] P. Calabrese. 2007. Cassella Waste Management, personal communication with S. Roe, CCS, 5 June.

household cleaning products, lithium batteries, electronic devices, and compact fluorescent bulbs.

Status of Group Approval

Approved.

Level of Group Support

Unanimous.

Barriers to Consensus

None.

Acronyms and Abbreviations

AFW	Agriculture, Forestry, and Waste Management
ANL	Argonne National Laboratory
ARS	Agricultural Research Service
ATFS	American Tree Farm System®
BAU	business-as-usual
BioPet	PioPower Evaluation Tool
BMP	best management practice
Btu	British thermal units
C	carbon
CBF	Chesapeake Bay Foundation
CCS	Center for Climate Strategies
CH_4	methane
CO	carbon monoxide
CO_2	carbon dioxide
CPI-U	consumer price index for all urban consumers
CSA	Community Supported Agriculture
DBED	[Maryland] Department of Business and Economic Development
DEP	[Maryland] Department of Environmental Protection
DGS	[Maryland] Department of General Services
DNR	[Maryland] Department of Natural Resources
DPW	[Maryland] Department of Public Works
DSM	demand-side management
eGRID	Emissions & Generation Resource Integrated Database
EIA	Energy Information Administration
ES	Energy Supply
FCMA	Forest Conservation Management Act
FIA	Forest Inventory and Analysis
FRLPP	Farm and Ranch Land Protection Program
FSC	Forest Stewardship Council
GHG	greenhouse gas
GIS	geographic information system
GPS	global positioning system
GREET	Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation
HDPE	High-density polyethylene
I&F	Inventory and Forecast
ISF	Institute for Sustainable Forestry
ISU	Iowa State University
LCFS	Low Carbon Fuels Standard
LDPE	Low-density polyethylene
LEED	Leadership in Energy and Environmental Design
MALPF	Maryland Agricultural Land Preservation Foundation
MAMWA	Maryland Association of Municipal Wastewater Agencies

MARBIDCO	Maryland Agriculture and Resource Based Industry Development Corporation
MCCC	Maryland Commission for Climate Change
MCE	Maryland Cooperative Extension
MDA	Maryland Department of Agriculture
MDE	Maryland Department of the Environment
MDOT	Maryland Department of Transportation
MDP	Maryland Department of Planning
MEA	Maryland Energy Administration
MET	Maryland Environmental Trust
MRA	Maryland Recycling Act
MSDE	Maryland State Department of Education
MSW	municipal solid waste
MWG	Mitigation Working Group
N_2O	nitrous oxide
NLEAP	Nitrate Leaching and Economic Analysis Package
NO_2	nitrogen dioxide
NOAA	National Oceanic and Atmospheric Administration
NPV	net present value
NRCS	Natural Resource Conservation Service
NREL	National Renewable Energy Laboratory
NRI	National Resources Inventory
O_3	ozone
O&M	operation and maintenance
PET	Polyethylene terephthalate
POS	Program Open Space
R&D	research and development
RCI	Residential, Commercial, and Industrial
RGGI	Regional Greenhouse Gas Initiative
RM	Resource Management [Contracting]
RPS	Renewal Portfolio Standard
SDAT	[Maryland] State Department of Assessment and Taxation
SHA	[Maryland] State Highway Administration
SLR	sea level rise (NOUN only)
SO_2	sulfur dioxide
SOCCR	State of the Carbon Cycle Report
SR	Source reduction
TLU	Transportation and Land Use
TWG	Technical Work Group
UM	University of Maryland
USACE	United States Army Corps of Engineers
US DOE	United States Department of Energy
USDA	United States Department of Agriculture
US EPA	United States Environmental Protection Agency
USFS	United States Forest Service

USFS-SPF	United States Forest Service–State and Private Forestry
USFWS	United States Fish and Wildlife Service
UTC	urban tree canopy
VMT	vehicle miles traveled
VT	Virginia Polytechnic Institute and State University
WARM	WAste Reduction Model
WEEE	Waste Electronic and Electrical Equipment Directive
WRI	World Resources Institute
WTE	waste-to-energy

Units of Measure

$/t	dollars per metric ton
$/tCO$_2$e	dollars per metric ton of carbon dioxide equivalent
$/MMBtu	dollars per million British thermal units
$MM	million dollars
gC/ha/year	grams of carbon per hectare per year
gCO$_2$e/kgN	grams of carbon dioxide equivalent per kilogram of nitrogen
gal/year	gallons per year
kW	kilowatt
kWh	kilowatt-hour
MMBtu	million British thermal units
MMt	million metric tons
MMtC	million metric tons of carbon
MMtCH$_4$	million metric tons of methane
MMtCO$_2$e	million metric tons of carbon dioxide equivalent
MtCe	metric tons of carbon equivalent
MtCO$_2$e	metric tons of carbon dioxide equivalent
MW	megawatt
MWh	megawatt hours
t/year	metric tons per year
tC/acre	metric tons of carbon per acre
tC/year	metric tons of carbon per year
tCO$_2$e	metric tons of carbon dioxide equivalent
t/ha/year	metric tons per hectare per year
tCO$_2$e/tN	metric tons of carbon dioxide equivalent per ton of nitrogen

Table I-59. 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$MM)	Discounted Costs (2007$MM)	GHG Reductions ($MMtCO_2e$)	Cost-Effective-ness ($/t)
2009	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	—	$0.00	$0.00	—	
2010	$0.98	$8.00	$0.77	$1.58	$0.93	$0.34	32,608	$2.07	$1.97	0.01	
2011	$2.02	$0.00	$0.77	$3.28	$1.91	$0.71	67,408	$3.45	$3.13	0.02	
2012	$3.14	$8.00	$1.54	$5.08	$2.97	$1.10	104,512	$5.69	$4.92	0.02	
2013	$4.32	$8.00	$2.31	$7.00	$4.09	$1.51	144,035	$8.03	$6.61	0.03	
2014	$5.58	$0.00	$2.31	$9.04	$5.28	$1.95	186,098	$9.70	$7.60	0.04	
2015	$6.92	$8.00	$3.08	$11.22	$6.55	$2.42	230,826	$12.25	$9.14	0.05	
2016	$7.87	$8.00	$3.85	$12.76	$7.45	$2.75	262,445	$14.28	$10.15	0.05	
2017	$8.88	$8.00	$4.62	$14.38	$8.40	$3.10	295,930	$16.38	$11.09	0.06	
2018	$9.94	$0.00	$4.62	$16.11	$9.41	$3.48	331,371	$17.79	$11.47	0.07	
2019	$11.07	$8.00	$5.40	$17.93	$10.47	$3.87	368,859	$20.05	$12.31	0.07	
2020	$12.25	$8.00	$6.17	$19.85	$11.60	$4.29	408,495	$22.39	$13.09	0.08	
Total									**$91.47**	**0.50**	**$183.81**

O&M = operation and maintenance; 2006$MM = million 2006 dollars; $MMtCO_2e$ = million metric tons of carbon dioxide equivalent; $/t = dollars per metric ton.

Maryland Climate Action Plan

Appendix D-2

Energy Supply

Energy Supply

Summary List of Priority Policy Options Recommended for Analysis

	Policy Option	GHG Reductions ($MMtCO_2e$)			Net Present Value 2008–2020 (Million $)	Cost-Effective-ness ($/$tCO_2e$)	Level of Support
		2012	2020	Total (2008–2020)			
ES-1	Promotion of Renewable Energy (Zoning and Siting Incentives for Centralized Facilities)	0.2	0.5	3.3	$100	$30.3	Unanimous
ES-2	Technology-Focused Initiatives for Electricity Supply (Biomass Co-Firing, Energy Storage, Fuel Cells, Landfill Gas, Clean Energy Incentives)	U	U	U	U	U	Unanimous
ES-3	GHG Cap-And-Trade (C&T) (With a Hypothetical Allowance Auction Price At $7/$tCO_2e$); Account for All Reduction Under an Auction-Based C&T (Note: Quantification Represents Current Regional Greenhouse Gas Initiative [RGGI] Program	U	16.96	U	-$235	U	Unanimous
ES-4	Combined Capture, Storage, and Reuse (CCSR) Incentives, Requirements, and Enabling Policies (Administration, Regulation, Liability, Incentives)	*Study presented for informational purposes only.*					N/A
ES-5	Clean Distributed Generation (DG): Standards, Incentives and Barrier Removal for DG, Including Combined Heat and Power (CHP), District Heating and Cooling, Landfill Gas, Solar, and Other Forms of Renewable Energy						Unanimous
	ES-5a Distributed Generation (DG)	0.3	1.1	6.7	$250	$37.5	
	ES-5b Combined Heat and Power (CHP)	0.3	1.0	6.3	$90	$14.4	
ES-6	Integrated Resource Planning (IRP) With or Without Re-Regulation or State Energy Plan	U	U	U	U	U	Unanimous
ES-7	Renewable Portfolio Standard (RPS)	5.2	13.8	100.7	$2,589	$25.7	Unanimous
ES-8	Efficiency Improvements and Repowering Existing Plants	1.2	2.0	17.9	$389	$21.8	Unanimous
	ES-8a Biomass Component						
	ES-8b Repowering Component	*Study presented for informational purposes only.*					N/A
ES-9	Carbon Tax	*Study presented for informational purposes only.*					N/A
ES-10	Generation Performance Standards (GPS)—1,125 pounds CO_2e/MWh	4.9	6.6	62.6	$2,659	$42.4	Unanimous
	Sector Total After Adjusting for Overlaps*	**11.9**	**24.6**	**194.2**	**$5,977**	**$30.8**	
	Reductions From Recent Actions	**4.8**	**12.2**	**88**	**$2,329**	**$26.5**	
	Sector Total Plus Minus Actions	**7.1**	**12.4**	**106.2**	**$3,648**	**$34.3**	

GHG = greenhouse gas; $MMtCO_2e$ = million metric tons of carbon dioxide equivalents; $/$tCO_2e$ = dollars per ton of carbon dioxide equivalent; U = Unquantified; N/A = not applicable; ES = Energy Supply; CO_2e/MWh = carbon dioxide equivalents per megawatt-hour.

*See explanation below:

Recent actions include those GHG reductions and costs associated with the new Maryland renewable portfolio standard (RPS). ES-7 proposes an RPS policy that results in GHG reductions in excess of the current Maryland RPS. The net differences between the proposed ES-7 policy and the current Maryland RPS are included in the "Sector Totals Minus recent Actions" results.

Overlap Discussion

The amount of carbon dioxide equivalents (CO_2e) emissions reduced in the policy options within the Energy Supply (ES) sector overlaps with some of the quantified benefits and costs of other policy options within ES and in other sectors. Those overlaps were identified and adjusted to eliminate double counting. The ES sector totals were reduced accordingly as shown in the chart above.

The following overview identifies specifically where those overlaps occurred and how they were resolved:

ES-1 addresses actions that promote the use of renewable energy sources, while ES-7 identifies a more aggressive renewable portfolio standard (RPS) for electric generators. It is likely that the electricity generated by the new renewable energy sources that are developed pursuant to ES-1 will be purchased by the large power producers that are required to comply with the RPS requirement of ES-7. Therefore, all greenhouse gas (GHG) reductions resulting from ES-1 are assumed to be captured in the ES-7 GHG-reduction calculation. As a result, 100% of the reductions and costs that correspond to ES-1 are assumed to be captured in the GHG reduction and cost results for ES-7.

ES-3 models the additional emissions reductions and cost savings resulting from Maryland's participation in the Regional Greenhouse Gas Initiative (RGGI). The emissions reductions and savings are included as "Reductions from Recent Actions," and not included in the "Sector Totals After Adjusting for Overlaps."

ES-8a evaluates the GHG reduction benefits and associated costs resulting from the increased use of biomass at existing plants for which increased use is economical. The amount of biomass needed to support this option may be limited by the concurrent demand for biomass associated with AFW-6 (Expanded Use of Forest and Farm Feedstocks and By-Products for Energy Production) in the Agriculture, Forestry, and Waste Management (AFW) Technical Work Group (TWG). Therefore, all emission reductions and costs associated with biomass to energy production for AFW-6 have been removed from the AFW Sector Total Minus Overlap row and are accounted for here in ES totals.

ES-1. Promotion of Renewable Energy (Zoning and Siting Incentives for Centralized Facilities)

Policy Description

This policy option focuses on encouraging renewable energy development by removing regulatory and financial barriers to large-scale centralized facilities as well as onsite generation. It is directed primarily on revising existing statutes and regulations to:

- Streamline and encourage, modernize zoning and siting rules, and processes;
- Ensure that any state resource planning process includes consideration of renewable energy projects;
- Develop a clean energy fund to provide for revolving loans (through bonds or any other effective financing mechanisms); and
- Make use of long-term contracts for offshore wind and renewables.

In addition, this option would include efforts to facilitate greater use of existing state authority for performance-based contracting of renewable energy projects. The goal of these proposals is to encourage investment in renewable energy by helping to overcome impediments to increased use in Maryland.

For purposes of this policy option, renewable sources include the following Tier 1 sources defined in the Maryland Renewable Portfolio Standard (RPS): solar energy, wind energy, qualifying biomass, methane (CH_4) from the anaerobic decomposition of organic materials in a landfill or wastewater treatment plant, geothermal energy, ocean energy (including energy from waves, tides, current, and thermal differences), fuel cells that produce energy from designated Tier 1 renewable energy sources, and small hydroelectric power meeting specified criteria (see Maryland Code, Sec. 7-701).

Policy Design

Goals: This option will achieve an increase in the use of Tier 1 renewable energy alternatives through the relaxation of zoning and siting requirements and the use of long-term contracts for Tier 1 electricity sources. Specifically, the policy targets an increase of Tier 1 renewable energy alternatives at the rate of 0.1% of total Maryland utility production, starting in 2009 and extending through 2020.

Timing: This policy would be intended to come into effect in 2009 and would continue indefinitely as an enabling mechanism for other climate-related policies.

Parties Involved: Maryland Public Service Commission (PSC), Maryland Department of Natural Resources (DNR), and Maryland Department of Environment (MDE).

Other: Energy service companies, financial community, renewable energy developers, environmental community, and local government.

Implementation Mechanisms

The Mitigation Working Group (MWG) recommends the revision of local zoning laws, the Certificate of Public Convenience and Necessity (CPCN) process before the PSC, and resource planning procedures by the PSC (as developed by appropriate state and local agencies) as measures to implement this policy.

In addition, the MWG recommends that the state develop model zoning ordinances and permitting code amendments to allow local governments to begin the conversation of establishing clean energy zones to enable streamlined planning and permitting approval.

Coordination with federal, state and local economic development authorities is needed to prioritize clean energy in certain economic development zones.

Related Policies/Programs in Place

There are several state efforts in place that are related to this option, as follows:

- Existing CPCN exemption for wind projects less than 25 megawatts (MW);
- RPS that requires a certain percentage of renewable electricity to be purchased by load-serving entities (LSE); and
- Large municipal purchases of clean energy with preferential regional purchasing clauses (e.g., Montgomery County Wind Power Purchasing Group).

Under an Indefinite Quantity Contract (IQC) process, Maryland Department of General Services (DGS) is currently finalizing the qualifications of a group of firms who develop renewable energy projects—specifically solar, wind and biomass—as the state plans to enter into a long term Power Purchase Agreement (PPA) with a successful qualified firm.

Type(s) of GHG Reductions

Renewable generation can reduce fossil fuel use in power generation and correspondingly reduce carbon dioxide (CO_2) emissions.

Estimated GHG Reductions and Net Costs or Cost Savings

	Policy Option	GHG Reductions ($MMtCO_2e$)			Net Present Value 2008–2020 (Million $)	Cost-Effective-ness ($/tCO$_2$e)	Level of Support
		2012	2020	Total (2008–2020)			
ES-1	Promotion of Renewable Energy (Zoning and Siting Incentives for Centralized Facilities)	0.2	0.5	3.3	$100	$30.3	Unanimous

GHG = greenhouse gas; $MMtCO_2e$ = million metric tons of carbon dioxide equivalents; $/tCO$_2$e = dollars per ton of carbon dioxide equivalent.

The policy evaluated includes the increase of Tier 1 renewable energy alternatives at the rate of 0.1% of total Maryland utility production each year from 2009 through 2020. These increases are assumed to result solely from the easing of zoning and site requirements and the use of long-term contracts for Tier 1 electricity sources. The current analysis does not quantify the effects or costs associated with establishing a clean energy fund. The increase in Tier 1 production is assumed to result in a comparable reduction in electricity production from coal. Greenhouse gas (GHG) reductions range from 0.17 million metric tons of carbon dioxide equivalents ($MMtCO_2e$) in 2012 to 0.50 $MMtCO_2e$ in 2020, with a cumulative reduction of 3.30 $MMtCO_2e$. The cost of these reductions is estimated to be 27.0 2005\$/tCO_2e (2005 dollars per metric ton of carbon dioxide equivalent).

Data Sources:

- Emission projections data come from either Center for Climate Strategies inventory and forecast studies of respective states, or publicly available data from the Energy Information Administration (EIA) *Annual Energy Outlook 2007* for states lacking detailed bottom up assessments.
- R.S. Means. 2007. *Heavy Construction Cost Data*. Kingston, MA.
- EIA. 2007. *Assumptions for the Annual Energy Outlook 2007: with Projections to 2030,* supplemental table spreadsheet “sup_t2t3.xls” for Mid-Atlantic States. Available at http://www.eia.doe.gov/oiaf/aeo/assumption/index.html
- Maryland Commission on Climate Change (MCCC). 2008. *Draft Straw Proposals of Policy Options*. Available at http://www.mdclimatechange.us/GHG_Carbon_Mitigation_WG.cfm
- Maryland Power Plant Research Program (PPRP). 2006. *The Potential for Biomass Co-firing in Maryland*. Available at http://esm.versar.com/PPRP/bibliography/PPES_06_02/PPES_06_02.pdf
- EIA Report entitled: “Assumptions for the Annual Energy Outlook 2006: with projections to 2025,” 2006.

Quantification Methods:

Emissions of GHG from displaced coal power were compared with GHG emissions from Tier 1 power sources used to replace coal power. The difference in emissions is the net GHG reduction for this policy option. Total costs are calculated from levelized net present value (NPV) costs of power production, adjusted for Maryland construction and fuel costs.

Key Assumptions:

Tier 1 renewable energy alternatives increase linearly over time at a rate of 0.1% per year for all in-state production.

Increases in Tier 1 renewable power displace only coal power production.

The renewable energy alternatives were assumed to be apportioned as follows: Wind, 65%; Landfill Gas, 10%; Biomass, 10%; Solar, 10%; and Geothermal, 5%.

Key Uncertainties

Development of financial mechanism by 2009.

Additional Benefits and Costs

Reduction in electric transmission and distribution (T&D) system; reduced air pollution; and increased space in landfills.

Feasibility Issues

System integration of intermittent power generation; adequacy of electric transmission capacity; restructuring of zoning and siting requirements, development of financial mechanism; restructuring of state planning procedures.

It is likely that there are technical feasibility issues regarding the degree to which biomass co-firing would lead to the risk of wear, corrosion, slagging and fouling in the combustion system.

Status of Group Approval

Approved.

Level of Group Support

Unanimous.

Barriers to Consensus

None.

ES-2. Technology-Focused Initiatives for Electricity Supply (Biomass Co-Firing, Energy Storage, Fuel Cells, Landfill Gas, Clean Energy Incentives)

Policy Description

Technology and innovation play a critical role in the development of economic processes, including energy production and use. Major progress in climate change policy requires improvements to technologies as well as increased rates of technology adoption and use. Trends toward smaller scale in energy production technology, combined with the impact of automation and remote system controls, present challenges to current business models and operational procedures. This policy is an umbrella covering several technology-related policy options that together can contribute to GHG emission reductions in Maryland.

Policy Design

Goals: This set of policies would provide state government and other private and public parties with resources and incentives for analysis, targeted research and development (R&D), market development, and adoption of GHG-reducing technologies not covered by other policies. The overall goals would be: to position Maryland as a world leader in climate-related technology development and deployment; to achieve actual emission reductions from technology investments; and to develop state industries with high in-state and export capability. The policy should specifically target landfill gas combustion for power generation, use of biomass co-firing in existing coal fired units, energy storage, and use of fuel cells.

Timing: This policy would be intended to come into effect in 2008 and 2009 and would continue indefinitely as an enabling mechanism for other climate-related policies.

Parties Involved: Maryland government and private and public partners on a voluntary basis.

Other: Not applicable.

Implementation Mechanisms

The MWG recommends the creation of an R&D budget line item to fund a small staff in the appropriate state agency, most likely the Maryland Energy Administration (MEA), or an agency to be determined. This group would follow technology trends and identify critical technology pathways, as well as opportunities for collaboration and funding from other sources.

If the effort does not overlap with current MEA policy, the state should fund the Maryland Clean Energy Center (MCEC) program, created by the state legislature this year to provide grants and incentives as they are identified by the state, along with other sources of public input into the prioritization process. Two models would be the California Public Interest Energy Research (PIER) program and the New York Energy Research and Development Agency (NYSERDA). Utilities would be able to apply as partners for these funds.

Finally, the state's regulated utilities and independent power producers (IPP) would be allowed to devote a percentage of their sales revenue to substantial R&D projects on a voluntary basis as part of their overall energy supply (ES) portfolios. The invested capital portion of these projects would be given advantageous cost recovery as an incentive to carry out such projects. This policy could be relaxed when effective climate change policy comes into effect, although there may still be merit in continuing some level of incentive for utility R&D effort even when climate policy is in place.

Related Policies/Programs in Place

There are several state efforts in place that are related to this option, as follows:

- Innovation, including biotechnology, agriculture, and transportation;
- Renewable development;
- Tax credits and federal incentives; and
- Technology-specific policies, such as hybrid vehicle or solar pilot programs and incentives.

Type(s) of GHG Reductions

Various, from no direct reductions to direct offset of emitting fuels and processes to actual uptake and use of GHGs, thus removing them from the atmosphere.

Estimated GHG Reductions and Net Costs or Cost Savings

By consensus, this option was not quantified.

Data Sources: Not applicable.

Quantification Methods: Not applicable.

Key Assumptions: Not applicable.

Key Uncertainties

Funding level stability.

Ability to identify productive technology pathways.

Measures of success and program oversight.

Additional Benefits and Costs

None.

Feasibility Issues

Requires broad range of skills for effective administration.

Status of Group Approval

Approved.

Level of Group Support

Unanimous.

Barriers to Consensus

None.

ES-3. Greenhouse Gas (GHG) Cap-And-Trade (C&T) (With a Hypothetical Allowance Auction Price At $7/tCO_2e$); Account for All Reduction Under an Auction-Based C&T (Note: Quantification Represents Current Regional Greenhouse Gas Initiative [RGGI] Program)

Policy Description

Use of competitive forces within a cap-and-trade (C&T) regime will provide the incentives for economic investment and efficient technological innovations necessary to achieve the desired environmental improvements. Under a GHG emissions trading program, the regulatory agency sets a maximum limit or *cap* on the total amount of emissions (in tons) of GHGs (e.g., CO_2 or carbon dioxide equivalent [CO_2e] for other covered gases). The *cap* limits emissions from all covered facilities in a specific sector (e.g., electric generation). The program generally requires that the *cap* will be reduced over a period of years to achieve emission reduction targets.

The regulatory agency implements an emissions trading program by creating and distributing a specific number of *allowances* for use by regulated entities. An *allowance* represents an authorization to emit a specific amount of a pollutant (generally measured in tons) during a particular *compliance period*. The total amount of *allowances* cannot exceed the *cap*, thereby limiting total emissions.

At the end of each compliance period, each regulated entity must demonstrate it possessed sufficient allowances to cover all emissions of the capped pollutant. If an entity releases emissions (for a particular compliance period) in excess of the allowances it holds, it can meet the program requirements by buying additional allowances from entities that have excess allowances due to reduced emissions. This exchange of allowances is called a *trade*. In effect, the seller is rewarded for reducing its pollution below its number of allowances, and the buyer must pay a premium for releasing emissions in excess of its allocated level.

Through trading, participants with lower costs of compliance can choose to over-comply and sell their additional reductions to participants for whom compliance costs are higher. In this fashion, overall costs of compliance are lower than they would be otherwise. Programs that sell or auction allowances, as opposed to distributing them freely, rely less on trading since the entity that over-complies with expected emissions reductions will avoid the cost of purchasing the allowances in the first place. The entity that requires additional allowances can purchase them at auction or from a secondary market. The compliance obligation for the C&T program can be imposed "upstream" (at the fuel extraction or import level) or "downstream" (at points of fuel consumption or points of emissions).

One key policy issue in designing a C&T program relates to the treatment of energy efficiency and renewable energy (EERE). Unless a C&T program is well designed, it will not assure the maximum achievable GHG reductions from EERE projects.

There are several policy options available to assure that EERE development results in overall CO_2 emission reductions under a GHG emissions trading program. For example, Maryland could adopt a key optional section of the model rule issued by the Regional Greenhouse Gas Initiative

(RGGI), a C&T program for large electric power plants. This optional section authorizes states to retire allowances on behalf of voluntary purchases of renewable energy. However, if EERE programs or projects are not accounted for under the cap (through the retirement of allowances or in setting the level of the cap) in any future GHG emissions trading program that might be established in Maryland, then they will not affect the overall level of CO_2 emissions.

Among the other important considerations in designing a C&T program are: the geographic scope, the sources and sectors to which it would apply; the baselines for these sources and sectors; the level and timing of the cap; and what, if any offsets, would be allowed. Other issues to consider include: which GHG are covered; whether there is linkage to other trading programs; banking and borrowing of allowances; and early reduction credit.

Maryland is already a partner in the RGGI. As a result, nearly all of the questions regarding the program design and implementation have been resolved through the RGGI process. The MWG supports the state's continued active involvement in RGGI and encourages consideration of the expansion of RGGI to beyond the power sector, if the federal government fails to enact a credible national C&T program in 2009. For the purpose of this recommendation a credible national program must require at least a 20% reduction from current emission levels for covered sectors by 2020.

Policy Design

Goals: Caps for electric power plants should match the RGGI goals, which are 2005 emissions starting in 2009 through 2014, followed by a 10% reduction through 2019. Other sectors could be included if RGGI were to expand by sector. If this were to happen the resulting reductions should contribute to the state goal, which is anticipated to be 25% below 2006 emissions by 2020 and 90% below 2006 emissions by 2050. These caps should be revisited periodically to reflect current scientific understanding of climate change.

Timing: The state should meet the timing requirements set by RGGI for electric power plants, specifically the adoption of Maryland's RGGI rule in sufficient time to allow a January 1, 2009 program start. Non-RGGI sectors should be studied for potential inclusion in RGGI and pursue complementary policies and measures in order to meet the state goal.

Parties Involved: As a member of RGGI, Maryland must coordinate with the other members on matters involving the electric power sector. The MWG believes that a credible national C&T program is preferable to regional efforts like RGGI and, as stated above, encourages enactment of such a program by Congress before the end of 2009. However, in the event this does not happen and the RGGI members seek expansion of the program to include other sectors, Maryland should design its program to blend into the expanded regional effort. Maryland should advocate for expansion of RGGI to as many sources as practical, including major industrial emitters, the transportation sector, and the buildings sector (particularly new state and university buildings). Inclusion of sectors that are easier to regulate can begin prior to more complicated sectors.

Other: For offsets that are a part of the C&T system, care should be taken that local jurisdictions can apply for offsets for qualifying programs they create.

Linkages to external comparable programs should be explored. The state should strongly advocate links to other regional or national programs of equal strength and effectiveness.

Implementation Mechanisms

There are three key implementation mechanisms: the point of regulation (entity responsible for compliance), initial allowance distribution, and offsets.

The first key implementation mechanism concerns the designation of the entity responsible for acquiring and surrendering allowances for emissions, or "point of regulation." In some sectors, such as major industrial emissions, this is simply the in-state entity operating the facility from which the emissions are released.

RGGI has adopted a production-based (smokestack) system for the electric power sector, but is considering modifying this approach to incorporate greater consideration of load-based (consumer) emissions. The Western Climate Initiative (WCI) states are considering a more load-based approach.

If RGGI were to expand to include additional sectors, there will likely be a need to vary the "point of regulation" depending on the sector. There are many pros and cons to each approach that should be comprehensively fleshed out in the program development phase.

The transportation sector offers a challenge because a program requiring the surrender of allowances from the end users of motor fuels would be complex and is generally thought to be unworkable. Therefore, transportation sector emissions should be regulated upstream, focusing on the entity that imports or distributes the petroleum in the state.

Natural gas (NG) also should be regulated upstream, again focusing on the entity that imports the NG into the state. Major industrial emissions should be regulated at the point of emissions, except to the extent emissions are associated with NG and petroleum already regulated upstream. Emissions of certain high global-warming potential gases may also be regulated upstream of their usage (e.g., at the distribution level) if more practical.

The second key implementation mechanism is how the state initially distributes allowances. Allowances may be distributed by auction or given free-of-charge to covered entities. The State of Maryland has decided to auction 100% of its RGGI allowances. Maryland may want to consider a different allowance distribution approach for new sectors if and when they are added.

The third key implementation mechanism concerns offsets. Offsets are out-of-sector emissions reductions or carbon sequestration projects recognized by the program as qualifying for allowance credit. Offsets must be measures that are not required by the program and, in most cases, cannot be required by any emissions reduction program. They provide an incentive for low-cost investments in emissions reductions as an alternative to higher-cost in-sector reductions or allowance purchases. Offsets should be subject to stringent standards to ensure their environmental integrity, and should be limited to guarantee that the overwhelming majority of emission reductions come from covered sectors. Any offsets allowed under the program should be real, verifiable, surplus, permanent, and enforceable.

Related Policies/Programs in Place

A Carbon Tax (ES-9) is seen as a complementary policy, applying to sectors not covered by C&T.

Type(s) of GHG Reductions

All six statutory GHGs (CO_2, CH_4, nitrous oxide [N_2O], hydrofluorocarbons [HFCs], perfluorocarbons [PFCs], and sulfur hexafluoride [SF_6])

Estimated GHG Reductions and Net Costs or Cost Savings

Model scenarios for the C&T policy are limited to the 10 RGGI states and the power sector. Runs were performed assuming two initial allowance allocation strategies: (1) all allowances are freely given to regulated sources, and (2) all allowances are auctioned. Due to the nature of some state emission caps and the state allowance budgets in 2020, allowance prices could not be projected to the exact dollar level. Instead, multiple runs were conducted assuming prices ranging from $1 to $7 per tons of carbon dioxide emissions (tCO_2). Given that Maryland has decided to auction all allowances, only those results are presented. Results from the free distribution model are given in the Annex to this report.

In the auction case with a hypothetical allowance price of $7 per ton of carbon dioxide equivalent ($7/$tCO_2e$), each state would utilize all its mitigation potential with a marginal cost (MC) less than $7/$tCO_2e$ before purchasing allowances from the auctioneer. As a result, the total emission reductions achieved by the 10 states in this case are 41.82 million metric tons of carbon dioxide ($MMtCO_2$). Although considerable amounts of unused mitigation potentials of some states (i.e., Maryland and Massachusetts) in the free granting case are associated with cost savings, the total cost savings of mitigation in the auction case (2.54 billion) are even higher than the total mitigation cost savings in the free granting case (1.53 billion). In addition, in the auction case many states would reduce more emissions than required by the state mitigation target. The reason is there is a penalty for each unit of CO_2 emitted even if it is below the cap—this is the price of an auctioned permit required to emit. However, the additional reductions achieved by these states can be saved for future use.

Comparing the two auction prices of $7 and $1, the amount states choose to reduce by mitigation options (41.82 $MMtCO_2$ vs. 39.98 $MMtCO_2$, respectively) and the amount to be bought from the auctioneer (127.44 $MMtCO_2$ vs. 129.28 $MMtCO_2$, respectively) differ slightly. The trend is the higher the auction price, the more the states choose to mitigate on their own and the less they buy from the auctioneer. The big difference of these two cases is the total auction cost, primarily due to the difference in the two auction price levels.

At an assumed allowance price of $7/$tCO_2e$ in 2020, regulated sources within Maryland can expect to mitigate 16.96 $MMtCO_2e$ at a total cost savings of $618 million. In addition, they will purchase 14.83 million allowances (1 allowance mitigates 1 ton of CO_2) at a total cost of $104 million. The net savings is therefore $514 million. This does not include any savings that might be realized through the expenditure or application of auction revenues ($104 million). The cost-effectiveness of the auction-based C&T is computed by dividing the total net cost (mitigation cost plus auction cost) by all the emission reductions undertaken by MD under the C&T. The resulting cost-effectiveness of the auction-based C&T is –$30.31/$tCO_2e$.

At an assumed allowance price of $1 per ton of carbon dioxide equivalent ($1/t$CO_2$e) in 2020, regulated sources within Maryland can expect to mitigate 16.05 MMtCO_2e at a total cost savings of $621 million. In addition, they will purchase 15.74 million allowances (1 allowance mitigates 1 ton of CO_2) at a total cost of $15.74 million. The net savings is therefore $605.6 million. Compared with the expected cost savings from mitigation without C&T ($408 million), the net C&T program savings to Maryland is $177 million in 2020. Again, this does not include any savings that might be realized through the expenditure or application of auction revenues ($15.74 million).

The assumption is that the cost associated with the auction of allowances is to be fully passed on to consumers. Under Maryland's deregulated environment, some portion of the cost may in fact be borne by the owners and shareholders of these facilities. Any portion of the allowance cost not passed along to consumers would represent additional savings in the cost per ton column.

Finally, no assumption is made concerning indirect impacts through the broader economy of costs or savings resulting from this policy.

Data Sources:

- Emission projections data come from either CCS inventory and forecast studies of respective states, or publicly available data from EIA *Annual Energy Outlook 2007* for states lacking detailed bottom up assessments.
- Reduction potentials and cost-effectiveness data of mitigation options for the states are used to develop the cost curves. The data sources are:
  - Connecticut Governor's Steering Committee (GSC) on Climate Change. 2005. *2005 CT Climate Change Action Plan*. Available at http://www.ctclimatechange.com/StateActionPlan.html
  - MCCC. 2008. *Maryland Climate Change Action Plan*. Available at http://www.mdclimatechange.us/index.cfm
  - Maine Department of Environmental Protection (DEP). 2004. *Final Maine Climate Action Plan 2004*. Available at http://www.maine.gov/dep/air/greenhouse/
  - Center for Clean Air Policy (CCAP) and New York GHG Task Force. 2003. *Recommendations to Governor Pataki for Reducing New York State Greenhouse Gas Emissions*. Available at http://www.ccap.org/pdf/04-2003_NYGHG_Recommendations.pdf
  - Rhode Island Greenhouse Gas Process (RI GHG). 2002. *Rhode Island Greenhouse Gas Action Plan*. Available at http://righg.raabassociates.org/
  - Vermont Governor's Commission on Climate Change (GCCC). 2007. *Final Report and Recommendations of the Governor's Commission on Climate Change*. Available at http://www.anr.state.vt.us/air/Planning/htm/ClimateChange.htm

- There are no direct mitigation options data for Maine, New Jersey, New Hampshire, and Delaware. MC curves for these four states are developed based on cost curves of Rhode Island, New York, Connecticut, and Maryland, respectively.

Quantification Methods:

In this study, a non-linear programming (NLP) model of emission allowance trading is used. This model is based on the well-established principles of the ability of unrestricted permit trading to achieve a cost-effective allocation of resources in the presence of externalities.[1] The model requires equalization of MC of all trading participants with the equilibrium permit price. This ensures minimization of total net compliance costs for each state and minimization of total abatement costs for the C&T program as a whole.[2]

The MC curves of the states are developed based on the reduction potential and mitigation cost-per-saving data of individual options that contribute to the emission reductions from the power sector. These options not only include those designed directly for the electricity supply sector (e.g., promotion of renewable energy utilization, repowering existing plants, generation performance standards [GPS]), but also include options in residential, commercial, and industrial sectors (RCI) that contribute to the reduction of electricity consumption (e.g., demand-side management [DSM], energy-efficient appliances, building codes). The emission reduction potentials of these options are adjusted by multiplying the percentage of electricity consumption by the total energy consumption in RCI. Options for RCI relating entirely to reduction of other fossil fuels consumption (e.g., gas, oil) are not included in the cost curves.

Key Assumptions:

The purpose of the simulations is to illustrate the economic impacts of the RGGI C&T program to Maryland under particular design scenarios.

All emissions considered are production based and are gross emissions (excluding sinks).

The economic modeling conducted in this study helps to analyze the potential GHG reductions and associated cost for Maryland under several scenarios of different design configurations using the following variables: allocation methods (auctioning vs. free granting of permits), hypothetical allowance prices (at the range of $1 to $7 per tCO_2).

A full list of assumptions adopted in the simulation model is presented in the Annex.

Key Uncertainties

Market prices are bound to fluctuate and allowance price spikes and crashes are not uncommon in new programs as the market gains experience. RGGI has incorporated a number of design

[1] See, for example, T. Tietenberg, 1985. *Emissions Trading: An Exercise in Reforming Pollution Policy,* Washington, DC, Resources for the Future.

[2] See, for example, B. Stevens, and A. Rose, 2002. "A dynamic analysis of the marketable permits approach to global warming policy: A comparison of spatial and temporal flexibility," *Journal of Environmental Economics & Management* 44(1):45–69; A. Rose, T. Peterson, and Z. Zhang, 2006. "Regional Carbon Dioxide Permit Trading in the United States: Coalition Choices for Pennsylvania," *Penn State Environmental Law Review* 14(2):203–229.

features to mitigate these tendencies, but only actual experience after allowances are offered for sale will prove the point. Emission reductions result when the supply of allowances is less than the unconstrained level of emissions. The RGGI cap was set several years ago and the precise quantity to force reduced emissions may not be found until the program has operated for one compliance period.

Additional Benefits and Costs

Additional benefits include the apparent effect that in anticipation of the program regulated entities are encouraged to make decisions resulting in reduced emissions before the program starts. The successful launch of a regional C&T program to limit GHG emissions will have an effect on policy makers in non-RGGI states and in Washington, D.C.

Feasibility Issues

Feasibility issues have been exhaustively studied through the RGGI development and design phases and have been resolved to the satisfaction of the 10 member states. Some questions remain, especially within the context of expansion of the program to additional sectors. The feasibility of extending C&T to stationary sources similar to power plants has been tested in the United States (sulfur dioxide [SO_2], nitrogen oxides [NO_x]), Europe and elsewhere. Application of the approach to some other sectors remains untested, and therefore, should continue to be studied carefully before implementation.

Status of Group Approval

Approved.

Level of Group Support

Unanimous.

Barriers to Consensus

None.

NOTE: This policy is a study product and presented here for informational purposes.

ES-4. Combined Capture, Storage, and Reuse (CCSR) Incentives, Requirements, and Enabling Policies (Administration, Regulation, Liability, Incentives)

Policy Description

Carbon capture, storage and reuse (CCSR) for integrated gasification combined cycle (IGCC) is being tested and shows promise as a technology for coal-fired power plants to move toward coal use with zero or very low emissions of CO_2. More recently, a new technology is being tested which can capture CO_2 from conventional coal-fired plants. IGCC involves partially combusting coal under high pressure to produce a synthetic gas, which is then turned into electricity via combined cycle combustion. Use of technology for existing plants could save considerable cost by retrofitting conventional plants, as well as building new IGCC power plants.

This policy is not quantified due to the uncertainty associated with cost and efficiency of these new technologies. However, for the purpose of illustration, the following analysis is offered using the assumptions stated. Compared with the cost of a standard pulverized coal unit, an IGCC with CCSR ranges from 26% to 48% more costly on a levelized basis. A single 600 MW unit would represent approximately 12% of Maryland's current coal capacity. The plant is assumed to come on line in 2013. Reductions in existing sources are assumed to come exclusively from traditional coal plants. Three carbon capture efficiencies based on analyses presented by the IPCC in their 2007 ES report were evaluated: low (81%), medium (86%) and high (91%). Transportation and geologic storage costs are from the range of values included in the IPCC technical report and assume a total of 250 kilometers of transportation prior to storage. GHG reductions ranged from 3.2 to 3.6 $MMtCO_2e$ in 2020. Cumulative GHG reductions through 2020 range from 25.8 to 28.8 $MMtCO_2e$. Depending on the carbon capture efficiency assumption, cost-effectiveness varies between $47.8 (2005$/tCO_2e) for the low efficiency assumption, $73.5(2005$/tCO_2e) for the medium efficiency assumption, and $104.2 (2005$/tCO_2e) for the high efficiency assumption. The following is offered for illustration:

	Policy Option	GHG Reductions ($MMtCO_2e$)			Net Present Value 2008–2020 (Million $)	Cost-Effective-ness ($/$tCO_2e$)	Level of Support
		2012	2020	Total (2008–2020)			
ES-4	Combined Capture, Storage, and Reuse (CCSR) Incentives, Requirements, and Enabling Policies (Administration, Regulation, Liability, Incentives)	0.0	3.4	27.2	$2,001	$73.5	N/A
	Low efficiency	0.0	3.2	25.8	$1,230	$47.8	
	Medium efficiency	0.0	3.4	27.2	$2,001	$73.5	
	High efficiency	0.0	3.6	28.8	$3,002	$104.2	

GHG = greenhouse gas; $MMtCO_2e$ = million metric tons of carbon dioxide equivalents; $/$tCO_2e$ = dollars per ton of carbon dioxide equivalent; N/A = not applicable.

Policy Design

Goals: Encourage the replacement of an existing coal-powered station or the retrofit of an existing plant with CCSR by 2020.

Timing: As noted above.

Parties Involved: All power producers operating qualifying facilities in Maryland, IPPs, and state regulators. Also, recognizing that these are emerging technologies, there will be a need to harmonize the legal and regulatory framework through coordination with other states and federal agencies.

Other: Not applicable.

Implementation Mechanisms

The MWG recommends the following key aspects to the implementation of this option in Maryland:

- Require development of the legal and regulatory frameworks needed for geologic storage of CO_2—new regulations should address issues of CO_2 ownership in storage and liability for the same. State environmental agencies should develop permitting processes for underground storage, including guidance on pipelines, drilling, storage, measurement, monitoring and verification.
- Support comprehensive assessments of geologic reservoirs at state and federal levels to determine storage potential and feasibility.
- Evaluate the feasibility of CO_2 transport via pipeline and "advanced sequestration" (i.e., mineralization, carbon nano-fibers) if Maryland determines it does not have sufficient in-state storage opportunities.
- Provide tax incentives for CCSR and seek grants and participation from the federal government. Joint projects should be sought with Pennsylvania and West Virginia as these states have similar facilities and coal shafts that can be used for sequestration.

Related Policies/Programs in Place.

None.

Type(s) of GHG Reductions

CO_2 from coal-fired power plants.

Estimated GHG Reductions and Net Costs or Cost Savings

This policy is presented as not quantified. Analysis presented under Policy Description is for illustration. The Data Sources, Methods and Assumptions support the illustration.

Data Sources:

- Emission projections data come from either CCS inventory and forecast studies of respective states, or publicly available data from EIA *Annual Energy Outlook 2007* for states lacking detailed bottom up assessments.
- R.S. Means. 2007. *Heavy Construction Cost Data*. Kingston, MA.
- EIA. 2007. *Assumptions for the Annual Energy Outlook 2007: with Projections to 2030*. Available at http://www.eia.doe.gov/oiaf/aeo/assumption/index.html
- MCCC. 2008. Draft Straw Proposals of Policy Options. Available at http://www.mdclimatechange.us/GHG_Carbon_Mitigation_WG.cfm
- Maryland PPRP. 2006. *The Potential for Biomass Co-firing in Maryland*. Available at http://esm.versar.com/PPRP/bibliography/PPES_06_02/PPES_06_02.pdf
- IPCC. 2007. *2007: Energy Supply*, In *Climate Change 2007: Mitigation of Climate Change.* Available at http://www.ipcc.ch/ipccreports/ar4-wg3.htm
- IPCC. 2005. *IPCC Special Report: Carbon Dioxide Capture and Storage*. Available at http://www.ipcc.ch/ipccreports/srccs.htm

Quantification Methods:

Emissions of GHG from displaced coal power were compared with GHG emissions from IGCC units used to replace existing coal power. The difference in emissions is the net GHG reduction for this policy option. Total costs are calculated from levelized NPV costs of power production, adjusted for Maryland construction and fuel costs. A range of costs is provided for this option, since it is an unproven technology and uncertainty exists with respect to actual construction and operations costs. The final GHG reduction and cost values reported are based on central tendency input parameter values.

Key Assumptions:

A single 600-MW IGCC plant comes on line in 2013.

Increases in IGCC power displace existing coal power production.

Recommended parameter values from the IPCC report are used to estimate costs and efficiencies for this option.

Key Uncertainties

CCSR technologies are under development and it is not known whether the efficiencies will ultimately fall within the IPCC projections. Likewise, the cost of these technologies may increase if currently unforeseen obstacles to commercialization are found, or costs may decrease if technological breakthroughs occur. Finally, while 2013 is generally believed to be a reasonable start of operations date for the first CCSR plant in Maryland, it is possible, for the reasons just stated and others that use of CCSR might be delayed.

It is unclear if and how the New Source Review (NSR) provisions of the Clean Air Act would affect the promotion of plant upgrades.

Additional Benefits and Costs

Reduced air pollution; installation of more efficient technology.

Feasibility Issues

Technology is currently in the demonstration stage.

Status of Group Approval

NOTE: This policy is a study product presented for informational purposes.

Level of Group Support

Not applicable.

Barriers to Consensus

Not applicable.

ES-5. Clean Distributed Generation (DG): Standards, Incentives and Barrier Removal for Distributed Generation (DG), Including Combined Heat and Power (CHP), District Heating and Cooling, Landfill Gas, Solar, and Other Forms of Renewable Energy

Policy Description

This policy option reflects a suite of financial incentives to encourage investment in distributed renewables and combined heat and power (CHP). Financial incentives for distributed renewables could include:

- Direct subsidies for purchasing/selling distributed renewable technologies given to the buyer/seller;
- Tax credits or exemptions for purchasing/selling distributed renewable technologies given to the buyer/seller;
- Tax credits or exemptions for operating distributed renewable energy facilities;
- Feed-in tariffs, which provide direct payments to distributed renewable generators for each kilowatt-hour (kWh) of electricity generated from a qualifying renewable facility;
- Tax credits for each kWh generated from a qualifying renewable facility;
- R&D funding to support development of distributed renewable technologies;
- Net metering;
- Financial incentives or assurance of cost recovery for regulated utilities that make reasonable and prudent investments in utility-owned or customer-owned distributed renewable energy resources; and
- A clean energy grants program.

Maryland should strive toward capital buy downs and production incentives so there is full payback over 25 to 30 years to those who install distributed renewable options.

CHP refers to any system that simultaneously or sequentially generates electric energy and utilizes the thermal energy normally wasted. CHP is sometimes called “recycled energy” because the same energy is used twice. The recovered thermal energy can be used for industrial process steam, space heating, hot water, air conditioning, water cooling, product drying, or nearly any other thermal energy need in RCI. The end result is significantly increased efficiency over generating electric and thermal energy separately. CHP can reduce GHG emissions by increasing the overall efficiency of fuel use and reducing transmission line loss with the co-location of heat and power facilities. CHP also lends itself to the use of biofuels, an important Maryland emphasis. However, there are numerous barriers to CHP, including inadequate information, institutional barriers, high transaction costs because of small projects, high financing costs because of lender unfamiliarity and perceived risk, “split incentives” between building owners and tenants, and utility-related policies, such as interconnection requirement, high standby rates, and exit fees. The lack of standard offer or long-term contracts, payment at avoided cost levels, and lack of recognition for emissions reduction value provided also creates obstacles. Policies to remove these barriers can include: improved interconnection policies, improved rates and fees policies, streamlined permitting, recognition of the emission reduction value provided by CHP and clean distributed generation (DG), financing packages and bonding programs, power procurement policies, and education and outreach.

Financial incentives for CHP could include: direct subsidies for purchasing/selling CHP systems given to the buyer/seller; tax credits, or exemptions for purchasing/selling CHP systems given to the buyer/seller; tax credits or exemptions for operating CHP systems; feed-in tariff, which is a direct payment to CHP owners for each kWh of electricity or British thermal unit (Btu) of heat generated from a qualifying CHP system; and tax credits for each kWh or Btu generated from a qualifying CHP system.

Policy Design

Goals: Undertake a concerted effort to revise its regulatory policies and remove institutional barriers in order to allow distributed renewable and CHP to compete on a level playing field with other sources of electric and thermal energy. Set a goal for distributed renewable generation equal to 1% of all electricity sales in the state by 2020, with a phase-in beginning in 2010. Set a goal for CHP equal to 15% of in-state CHP technical potential at commercial and industrial facilities by 2020, with a phase-in beginning in 2010.

Timing: As noted above.

Parties Involved: Financial incentives would be administered by a state agency and provided to individuals, commercial enterprises, and industrial enterprises.

Other: A source of funds to cover these financial incentives would need to be determined. It may be possible to link incentives to (or make them conditional to) the manufacture within Maryland of associated equipment.

Implementation Mechanisms

The MWG recommends the use of the following mechanisms as necessary to achieve the goals stated under Policy Design above:

- Information and education,
- Technical assistance,
- Financial incentives,
- Regulatory policies, and
- Codes and standards.

Related Policies/Programs in Place

None.

Type(s) of GHG Reductions

Reductions in emissions of CO_2 from combustion sources.

Estimated GHG Reductions and Net Costs or Cost Savings

The incentives and other mechanisms proposed in this option generally benefit two classes of technologies: DG and CHP. These have been analyzed separately and may be aggregated to reflect the total impact of the measures themselves. The results in the Summary table are broken out by technology because the results from each are quite different. For example, the expected cost per ton of CO_2e mitigated for DG technologies is $37.5. This compares to a cost of $14.4 per ton mitigated for the CHP technologies. Over the study period of 2008 through 2020, CHP incentives and measures are projected to mitigate 6.3 $MMtCO_2e$, while DG measures are expected to mitigate 6.7 $MMtCO_2e$.

	Policy Option	GHG Reductions ($MMtCO_2e$)			Net Present Value 2008–2020 (Million $)	Cost-Effective-ness ($/t$CO_2e$)	Level of Support
		2012	2020	Total (2008–2020)			
ES-5	Clean Distributed Generation (DG): Standards, Incentives and Barrier Removal for DG, Including Combined Heat and Power (CHP), District Heating and Cooling, Landfill Gas, Solar, and Other Forms of Renewable Energy						Unanimous
	ES-5a Distributed Generation (DG)	0.3	1.1	6.7	$250	$37.5	
	ES-5b Combined Heat and Power (CHP)	0.3	1.0	6.3	$90	$14.4	

GHG = greenhouse gas; $MMtCO_2e$ = million metric tons of carbon dioxide equivalents; $/t$CO_2e$ = dollars per ton of carbon dioxide equivalent.

Data Sources:

- Emission projections data come from either CCS inventory and forecast studies of respective states, or publicly available data from EIA *Annual Energy Outlook 2007* for states lacking detailed bottom up assessments.
- R.S. Means. 2007. *Heavy Construction Cost Data*. Kingston, MA.
- EIA. 2007. *Assumptions for the Annual Energy Outlook 2007: with Projections to 2030*. Available at http://www.eia.doe.gov/oiaf/aeo/assumption/index.html
- MCCC. 2008. *Draft Straw Proposals of Policy Options*. Available at http://www.mdclimatechange.us/GHG_Carbon_Mitigation_WG.cfm

- Maryland PPRP. 2006. *The Potential for Biomass Co-firing in Maryland*. Available at http://esm.versar.com/PPRP/bibliography/PPES_06_02/PPES_06_02.pdf
- IPCC. 2007. *2007: Energy Supply*, In *Climate Change 2007: Mitigation of Climate Change.* Available at http://www.ipcc.ch/ipccreports/ar4-wg3.htm
- ACEEE. 2008. *Maryland's Clean Energy Future: Potential for Energy Efficiency and Demand Response to Meet Electricity Demands in Maryland*. Available at http://www.aceee.org/pubs/e082.htm
- NREL and GRI. 2003. *Gas-Fired Distributed Energy Resource Technology Characterizations*. Available at http://www.nrel.gov/analysis/pdfs/2003/2003_gas-fired_der.pdf

Quantification Methods:

Emissions of GHG from displaced coal power were compared with GHG emissions from CHP and DG sources. The difference in emissions is the net GHG reduction for this policy option. Total costs are calculated from levelized NPV costs of power production, adjusted for Maryland construction and fuel costs.

Key Assumptions:

The coal replacements in CHP are assumed to be 90% NG and 10% biomass. The DG replacements are 50% wind and 25% each of landfill gas and solar/photovoltaic (PV) technology.

For CHP, 15% of total technical potential (613 MW of 4084 MW) could be economically achieved.

For DG, 1% of total projected 2025 in-state energy production (495 MW) could be economically achieved.

CHP and DG use increases linearly over a 15-year period, starting in 2010.

Existing coal is displaced by these options.

Key Uncertainties

It is unclear what level incentives need to be to encourage the installation of DG. Additionally, information about CHP in Maryland is limited, leading to uncertainty among policy makers and the regulated community.

Additional Benefits and Costs

Reduced dependence on fossil fuels with use of biofuels; reduced air pollution.

Feasibility Issues

Design and implementation of tax credits; decreasing real or perceived risk associated with financing.

Status of Group Approval

Approved.

Level of Group Support

Unanimous.

Barriers to Consensus

None.

ES-6. Integrated Resource Planning (IRP) With or Without Re-Regulation or State Energy Plan

Policy Description

Integrated Resource Planning (IRP) is a regulatory process by which alternative solutions for reliably meeting electric demand are identified and evaluated to determine a least-cost or least-risk approach to achieving specific goals. The goal of IRP is to evaluate the costs, benefits, and risks of feasible options for meeting or modifying electric demand on a consistent basis. Accomplishing this goal requires an objective review of ES options (from conventional and renewable energy sources) and energy-efficiency options (e.g., DSM) prior to approving utility expansions of generation or transmission. Although the PSC utilized IRP from the late 1980s through the mid-1990s, this regulatory approach was discontinued when the state restructured its electric markets pursuant to the Electric Customer Choice and Competition Act of 1999.

IRP can be implemented in states with traditional approaches for regulating electric utilities or in those with market-based regulation. However, policy makers must carefully design the IRP framework to assure its effectiveness under the existing regulatory regime.

IRP provides a state resource adequacy method that evaluates many different options for meeting future electricity demands and selects the optimal mix of resources that minimizes the cost of electricity supply while meeting reliability needs and other objectives, such a increasing the state's production of renewable energy sources. An IRP framework would strive to achieve the following:

- Evaluate all options, from the supply and demand sides, in a fair and consistent manner;
- Minimize risks of cost increases to all stakeholders;
- Consider environmental impacts (including GHG emissions from in-state and out-of-state generation sources serving Maryland customers); and
- Create a flexible plan that allows for uncertainty and permits adjustment in response to changed circumstances.

The use of IRP would help to better align environmental and ES policies because it would require consideration of more options than current law and would require the consideration of a longer time horizon in making resource decisions. IRP could be accomplished by action on the part of the PSC to establish a process by which the state determines energy resources needed to meet demand and issues a competitive Request for Proposal (RFP) to meet that demand. The PSC can determine the parameters of the RFP that meet the overall goals of the state: electricity supply and reliability, demand reductions, and environmental protection in the most cost-effective manner to the consumer. Also the PSC could direct or encourage utilities to invest in advanced metering, information exchange infrastructure and usage control technologies to enable customers to reduce their electricity consumption and demand.

Moreover, in the IRP process, the PSC should consider the risk of cost increases associated with future regulation of emissions of GHG (e.g., CO_2), conventional pollutants (e.g., NO_x and SO_2) and hazardous pollutants (e.g., mercury) when evaluating supply-side (e.g., new power plants) and DS (e.g., EE) resource options. In addition, the IRP plans should evaluate a broad range of possible fuel costs and consider the risks of fuel price increases and volatility. The plans also should consider the risk mitigation benefits of EERE. The MWG recommends that Maryland enact regulatory or legislative changes as needed to implement an IRP process consistent with the Policy Design and Policy Description described here.

Policy Design

Goals: To develop a comprehensive state resource adequacy plan for Maryland to meet the reliability, environmental, and economic policies of the state. The plan should support and attempt to balance all three goals.

Timing: The IRP process could be implemented by 2009. The PSC can conduct a hearing and get draft resource needs to meet LSE demand in 2008 with the first IRP plan and RFP issued by early 2009.

Parties Involved: PSC, MEA, MDE, regulated electric utilities, environmental and consumer advocates, renewable energy industry, EE industry, financial community.

Implementation Mechanisms

This is an option that requires changes to PSC rules or new legislation.

Related Policies/Programs in Place

The PSC is currently pursuing a number of proceedings and reports examining IRP-related issues at policy and detailed program levels. These proceedings and reports include Docket 9111 (DSM and EE programs), Docket 9117 (utility provision of standard offer service), and the December 2007 interim report to the legislature on electricity regulation and regulatory structure.

Numerous other states have implemented IRP and can provide examples for Maryland. Delaware is currently working on implementation of its IRP, and its plan should be considered in developing regulatory options. In addition, the National Action Plan for Energy Efficiency (NEEAP), coordinated by the U.S. Department of Energy (US DOE) and the Environmental Protection Agency (EPA), has compiled information on IRP best practices (see http://www.epa.gov/cleanenergy/pdf/napee/napee_chap3.pdf), and the Lawrence Berkeley National Laboratory has conducted extensive research analyzing the treatment of EERE in the IRPs of more than a dozen western states. (See http://eetd.lbl.gov/ea/ems/rplan-pubs.html.)

Type(s) of GHG Reductions

Greater reliance on EERE would reduce dependence on electricity produced by burning coal and other fossil fuels, thereby reducing emissions of CO_2 and other GHGs.

Estimated GHG Reductions and Net Costs or Cost Savings

By consensus, this option was not quantified.

Data Sources: Not applicable.

Quantification Methods: Not applicable.

Key Assumptions: Not applicable.

Key Uncertainties

Not applicable.

Additional Benefits and Costs

Reduced dependence on fossil fuels, reduced air pollution, and enhanced electric resource portfolio diversity.

Feasibility Issues

Feasibility issues are focused on the ability to implement the required changes to PSC rules or pass new legislation.

Status of Group Approval

Approved.

Level of Group Support

Unanimous.

Barriers to Consensus

None.

ES-7. Renewable Portfolio Standard (RPS)

Policy Description

RPS is a policy requiring investor-owned electric utilities and power importers to supply a certain percentage of retail electricity from renewable energy sources by a stipulated date. Utilities can satisfy the RPS requirement by generating renewable energy themselves or by purchasing renewable energy credits from a renewable energy generator. A renewable energy credit is equal to 1 kWh of eligible and verified renewable electricity produced. Eligible renewable sources and EE applications are defined in the current RPS.

Currently, Maryland's RPS includes the following components:

- Tier 1 resources (truly clean renewables) must constitute 1% of load in 2006, increasing to 20% in 2022;
- Tier 2 resources (which are less environmentally friendly) may currently constitute 2.5% of load, but will decrease to 0% by 2019;
- Solar PV must constitute 0.005% of load in 2008, increasing to 2% by 2022;
- The alternative compliance fee (ACF) is $20/MWh for Tier 1 and $15/MWh for Tier 2. Load associated with industrial sources has a lower ACF. The solar ACF starts at $450/MWh in 2008 and decreases to $50/MWh by 2023.
- Renewable projects in the PJM[3] region or a distribution region adjacent to the PJM region are eligible for Maryland renewable energy credits. This stretches the geographic scope from Illinois to New York to Virginia.
- Maryland is the only state that allows existing hydropower in its RPS. Therefore, Maryland ratepayer dollars are going to operators of existing hydropower dams in other states.
- This proposed policy would increase the Tier 1 requirements from 20% in 2022 to 20% in 2020.
- The MWG recommends the enactment of an RPS with these features and standards.

Policy Design

Structure: Strengthen the existing RPS to achieve 20% renewable energy by 2020, ramping up from a start data of 2008. No changes are made to the Tier 2 timeline or percentages. In addition:

[3] A regional transmission organization (RTO) that coordinates the movement of wholesale electricity in all or parts of Delaware, Illinois, Indiana, Kentucky, Maryland, Michigan, New Jersey, North Carolina, Ohio, Pennsylvania, Tennessee, Virginia, West Virginia and the District of Columbia.

- Reduce the size of the geographic region to the core PJM states—Maryland, Pennsylvania, Delaware and New Jersey;
- Raise the ACF to $50;
- Remove existing hydropower from the list of eligible resources; and
- Give 10% extra credit for projects that create substantial numbers of jobs in Maryland.

Timing: As noted above.

Parties Involved: All LSEs providing electricity over utility distribution lines in Maryland. The RPS requirement applies to electricity supplied to Maryland customers.

Other: Not applicable.

Implementation Mechanisms

This is a policy requiring a legislative act by the Maryland legislature.

Related Policies/Programs in Place

The option is a strengthened version of the existing RPS.

Type(s) of GHG Reductions

CO_2 from displaced coal, natural gas combined cycle (NGCC) and combustion turbine facilities; CH_4 through the use of animal waste-to-energy (WTE) and landfill-gas-to-energy (LFGE) resources; and aerosols from displaced coal.

Estimated GHG Reductions and Net Costs or Cost Savings

	Policy Option	GHG Reductions ($MMtCO_2e$)			Net Present Value 2008–2020 (Million $)	Cost-Effective-ness ($/$tCO_2e$)	Level of Support
		2012	2020	Total (2008–2020)			
ES-7	Renewable Portfolio Standard (RPS)	5.2	13.8	100.7	$2,589	$25.7	Unanimous

GHG = greenhouse gas; $MMtCO_2e$ = million metric tons of carbon dioxide equivalents; $/$tCO_2e$ = dollars per ton of carbon dioxide equivalent.

This policy evaluates the net changes in GHG emissions as a result of the implementation of a RPS. The requirements of the standard are outlined in the Policy Description section and represent an increase over current legislation of 20% for Tier 1 by 2022 (see Policy Description). The Tier 1 renewable energy alternatives are assumed to be apportioned as follows: wind, 80%; landfill gas, 2%; biomass, 10%; and geothermal, 8%. Solar and Tier 2 sources were not implemented, as the requirements of the policy are already met by existing hydropower. Hydropower is assumed to go to zero in 2019, as with the current RPS. Tier 1 RPS was initiated in 2006 and Tier 2 in 2008. Cumulative GHG reductions through the study period are estimated to be 100.7 $MMtCO_2e$ at a cost per ton mitigated of $25.7.

Maryland has recently updated its RPS to a new standard increasing the requirements for Tier 1 renewables in its portfolio from 9.5% to 20%, which will result in significant GHG reductions over the long term. The difference between the current Maryland RPS and the RPS proposed in this document is the timing of meeting the 20% Tier 1 standard. The current Maryland policy specifies the 20% goal be met by 2022, while the policy proposed in this document sets the date as 2020. The table below provides a quick comparison of previous and current Maryland RPS policies with the RPS policy proposed in this document.

	Policy Option	GHG Reductions ($MMtCO_2e$)			Net Present Value 2008–2020 (Million $)	Cost-Effective-ness ($/$tCO_2e$)	Level of Support
		2012	2020	Total (2008–2020)			
ES-7	Renewable Portfolio Standard (RPS)	5.2	13.8	100.7	$2,589	$25.7	Unanimous
	Previous Maryland RPS	3.0	4.6	48.4	$1,513	$31.2	
	Current Maryland RPS	4.8	12.2	88.0	$2,329	$26.5	
	Difference between Current Maryland RPS and RPS proposed in this document	0.4	1.6	12.7	$260.17	$0.8	

GHG = greenhouse gas; $MMtCO_2e$ = million metric tons of carbon dioxide equivalents; $/$tCO_2e$ = dollars per ton of carbon dioxide equivalent.

Data Sources:

- Emission projections data come from either CCS inventory and forecast studies of respective states, or publicly available data from EIA *Annual Energy Outlook 2007* for states lacking detailed bottom up assessments.
- R.S. Means. 2007. *Heavy Construction Cost Data*. Kingston, MA.
- EIA. 2007. *Assumptions for the Annual Energy Outlook 2007: with Projections to 2030*. Available at http://www.eia.doe.gov/oiaf/aeo/assumption/index.html
- MCCC. 2008. *Draft Straw Proposals of Policy Options*. Available at http://www.mdclimatechange.us/GHG_Carbon_Mitigation_WG.cfm
- Maryland PPRP. 2006. The Potential for Biomass Co-firing in Maryland. Available at http://esm.versar.com/PPRP/bibliography/PPES_06_02/PPES_06_02.pdf
- Maryland General Assembly (SB 209). 2008. RPS Percentage requirements.

Quantification Methods:

Emissions of GHG from coal were compared with GHG emissions from Tier 1 renewables used to replace coal power production. The difference in GHG emissions from coal to renewables is the net GHG reduction for this policy option. Total costs are calculated from levelized NPV costs of power production, adjusted for Maryland construction and fuel costs.

Key Assumptions:

Coal is the only power source displaced by Tier 1 renewable energy. The Tier 1 renewable energy alternatives are assumed to be apportioned as follows: wind, 80%; landfill gas, 2%; biomass, 10%; and geothermal, 8%. Solar and Tier 2 sources were not implemented, as the requirements of the policy are already met by existing hydropower. Hydropower is assumed to go to zero in 2019, as with the current RPS. Tier 1 RPS was initiated in 2006 and Tier 2 in 2008.

Key Uncertainties

Requirements for 10% extra credit, timing for legislation. The current estimates do not include provisions of subsection (a)(2) from section 7-703 of the RPS standard. Those exclusions will alter the total GHG reductions and associated costs.

Additional Benefits and Costs

Reduced air pollution; reduced dependence on fossil fuels.

Feasibility Issues

System integration of intermittent power generation; adequacy of electric transmission capacity.

It is likely that there are technical feasibility issues regarding the degree to which biomass co-firing would lead to the risk of wear, corrosion, slagging and fouling in the combustion system.

Status of Group Approval

Approved. *NOTE: One portion (8b) of this policy is a study product and is presented here for informational purposes.*

Level of Group Support

Unanimous.

Barriers to Consensus

None.

ES-8. Efficiency Improvements and Repowering Existing Plants

Policy Description

This policy would promote the identification and pursuit of cost-effective emissions reductions from existing generating units through improving their operating efficiency, adding biomass, or other fuel changes. This policy would complement GPS (which applies to new plants and new units) by addressing existing units. Given that CO_2 emissions have not previously been the focus of state regulation, and given that existing units have not been the focus of resource planning, it is expected that there are as-yet unidentified opportunities to reduce emissions from existing facilities that will be cost-effective, particularly once CO_2 limits are in place. This policy would, in time, result in the identification of a portfolio of technological options for reducing GHG emissions and allow state utilities to share the opportunities they have identified.

Key aspects of the options include

- Requiring utilities to evaluate their existing generating units for opportunities to improve their emissions profile through efficiency improvements, the addition of biomass or other fuel changes. This evaluation would be part of an overall plan identifying cost-effective options for reducing system CO_2 emissions on a short-term and long-term basis.
- Requiring utilities to pursue cost-effective options for reducing their emissions profile through measures identified above.
- Creating financial incentives that reward such emissions reductions. The terms "cost-effective" would be defined by some objective measure, such as cost per ton of carbon equivalent.

The MWG recommends the enactment of planning and emission reduction requirements that are consistent with this Policy Description and Policy Design.

Policy Design

Goals: The repowering option should seek to co-fire biomass at existing coal stations at a maximum statewide average rate of 8% of total energy input by 2015. The policy would initiate in 2010 and reach the 8% goal in 2014.

Note: An additional measure was studied in the development of this policy, but was not recommended for adoption by the MWG. The information is retained here as a study product of the MWG. This additional measure is identified as policy "8b" and would set a goal of repowering 30% of eligible coal stations with NG by 2020.

Timing: As noted above.

Parties Involved: The option applies to Maryland electric LSEs.

Other: Not applicable.

Implementation Mechanisms

The planning and emission reduction requirements would be implemented through processes already implemented by the Public Utilities Commission (PUC).

Related Policies/Programs in Place

The option is an important counterpart to the GPS, which only covers new financial commitments. It complements a C&T policy by ensuring that utilities pursue cost-effective potential emission reductions, rather than the more obvious option of purchasing emission allowances (with the projected price of allowances being a key part of the definition of "cost-effective" reductions).

Type(s) of GHG Reductions

All three major GHG emissions (i.e., CO_2, CH_4, N_2O).

Estimated GHG Reductions and Net Costs or Cost Savings

	Policy Option	GHG Reductions ($MMtCO_2e$)			Net Present Value 2008–2020 (Million $)	Cost-Effective-ness ($/tCO_2e$)	Level of Support
		2012	2020	Total (2008–2020)			
ES-8	Efficiency Improvements and Repowering Existing Plants; ES-8a, Biomass Component	1.2	2.0	17.9	$389	$21.8	Unanimous
	ES-8b Repowering Component	0.5	2.9	15.5	$980	$63.2	N/A

GHG = greenhouse gas; $MMtCO_2e$ = million metric tons of carbon dioxide equivalents; $/$tCO_2e$ = dollars per ton of carbon dioxide equivalent; N/A = not applicable.

This policy option evaluates the effect of co-firing biomass in existing coal plants. The biomass portion of the policy assumes that biomass provides 8% of power at existing coal-fired plants. The transition to biomass starts in 2010 and is fully implemented in 2014. The cost associated with biomass is assumed to be $3.40 per million Btu, based on values in a 2006 biomass feasibility report prepared for the State of Maryland, entitled "The Potential for Biomass Co-firing in Maryland" (DNR 12-2242006-107, PPES-06-02).

Total GHG reductions through the study period yield 17.8 $MMtCO_2e$. Biomass is expected to cost about 21.8 $/$tCO_2e$.

The repowering portion of this policy (8b) assumes that by 2020 several coal-powered stations in Maryland are repowered with NGCC technology. In practice, this will be a lumpy process, with steps in GHG reductions achieved as new repowered units come online. For simplicity, the option was modeled as NGCC performance, replacing existing coal performance at a rate of 3% per year, starting in 2011. The conversion of coal plants to NG may reduce the effect of the biomass option. This reduction has not been quantified.

Data Sources:

- Emission projections data come from either CCS inventory and forecast studies of respective states, or publicly available data from EIA *Annual Energy Outlook 2007* for states lacking detailed bottom up assessments.
- R.S. Means. 2007. *Heavy Construction Cost Data*. Kingston, MA.
- EIA. 2007. *Assumptions for the Annual Energy Outlook 2007: with Projections to 2030*. Available at http://www.eia.doe.gov/oiaf/aeo/assumption/index.html
- MCCC. 2008. *Draft Straw Proposals of Policy Options*. Available at http://www.mdclimatechange.us/GHG_Carbon_Mitigation_WG.cfm
- Maryland PPRP. 2006. *The Potential for Biomass Co-firing in Maryland*. Available at http://esm.versar.com/PPRP/bibliography/PPES_06_02/PPES_06_02.pdf

Quantification Methods:

Emissions of GHG from coal were compared with emissions from co-fired biomass with the same heating potential. Additionally, coal GHG emissions were compared with GHG emissions from equivalent NGCC power units for the repower portion of this policy option. The difference in emissions from coal to biomass and NGCC is the net GHG reduction for this policy option. Total costs are calculated from levelized NPV costs of power production, adjusted for Maryland construction and fuel costs.

Key Assumptions:

Biomass co-firing initiates in 2010 and increases linearly over a 5-year period to a maximum of 8% of energy input at converted plants. This uniform 8% rate is an average. It is recognized that individual coal units will have varying capabilities to cost-effectively accept biomass.

Estimated 'Warrior Run' conversion costs are representative of future conversion costs.

Increased demand for biomass does not alter fuel costs.

Conversion from coal to NGCC occurs at a rate of 3% per year, starting in 2010.

Existing coal power is displaced by biomass and NGCC.

The cost associated with biomass is assumed to be $3.40 per million Btu, based on values in a 2006 biomass feasibility report prepared for the State of Maryland, entitled "The Potential for Biomass Co-firing in Maryland" (DNR 12-2242006-107, PPES-06-02).

Key Uncertainties

This analysis used a conservative set of assumptions regarding the availability of biomass feedstock within short distances of candidate power plants. The use of this resource for this purpose may compete with other recommendations under considerations by the MWG. These assumptions must be reevaluated if competing uses for this resource are also recommended.

It is unclear how the NSR provisions of the Clean Air Act would affect the promotion of plant upgrades.

Additional Benefits and Costs

Reduced air pollution; reduced dependence on fossil fuels.

Feasibility Issues

It is likely there are technical feasibility issues regarding the degree to which biomass co-firing would lead to the risk of wear, corrosion, slagging, and fouling in the combustion system.

Status of Group Approval

Biomass component (8a) approved. *NOTE: The remainder of this policy is a study product and presented here for informational purposes.*

Level of Group Support

Biomass component - unanimous.

Barriers to Consensus

None.

ES-9. Carbon Tax

Policy Description

A carbon tax would be a tax on fossil fuels according to the amount of CO_2 emitted by their combustion. Carbon tax and C&T systems work toward similar ends in opposite ways. With C&T, the government sets a limit on the tons of pollution that will be released and the market establishes the price. With a carbon tax, the government sets the price and the market drives the level of emissions. The carbon tax and C&T programs are seen as complementary measures. One of the benefits of the tax is it can be more easily applied across all sectors. However, the ES Technical Work Group (TWG) recommends that the C&T program should be the primary market mechanism, with the carbon tax used as a supplementary measure in those sectors where transaction costs or other concerns make the use of C&T less desirable. Like most market-based approaches, it should be applied as broadly as possible, and would be best if applied nationwide.

On the negative side, it is politically difficult to impose a new tax, particularly since other taxes are expected to be rise to cover the Maryland budget deficit. Many economists argue the carbon tax is the most efficient way to ensure that product prices reflect the cost of GHG emissions generated in their manufacture and use. Administrative costs are low for the carbon tax and the impact on prices is predictable. The tax could be imposed upstream based on, for example, the carbon content of fuels (electricity generators or distributors) at the point of combustion and emission or at the point of sale (gasoline, NG). Although taxed entities would pass some or all of the cost on to consumers, there would be competitive pressure to find cost-effective ways to lower (or offset) emissions. Consumers who see the implicit cost of GHG emissions in products and services could adjust their behavior to lower emissions and reduce cost. Revenues collected could offset other taxes, be applied to incentivize low emission alternatives, be directed for relief to parties that are disproportionately impacted by the tax, or rebates could be created for CO_2 controls or offsets that prevent atmospheric emissions.

It is assumed that the cost of the tax would be passed down ultimately to the consumer, such as residential and commercial utility ratepayers for electricity. In order to achieve the stated goal, the amount of the tax must be high enough to trigger financial and behavioral decisions toward conservation or a shift to lower emitting fuels.

The MWG does not recommend the enactment of a carbon tax.

Policy Design

Goals: Make the cost of inefficient or higher CO_2 emitting activities more expensive than alternatives, thereby creating a financial incentive to change behavior away from activities that result in CO_2 emissions. The tax should include safety valves to reduce low-income impacts and minimize detrimental economic consequences. One option is to make the tax “revenue neutral,” (an equal amount of other state taxes would be reduced so the “net” to the state is zero). Another option might be that the revenue from the tax could be used to develop or promote alternatives that reduce CO_2 emissions. The amount of the tax should be high enough to contribute to the reduction targets specified in the C&T option (see ES-3).

Timing: Pegged to the timing of the C&T option (see ES-3).

Parties Involved: Major payers would be refiners or distributors of transportation and heating fuels in Maryland and commercial and industrial sources consuming energy for production or other commercial use.

Other: The TWG recognizes more in-depth analysis of the carbon tax and its interactions with the C&T and other policies will be required than is possible within the current process. Therefore, it is recommended that a Technical Advisory Committee be convened to study the proposal in greater depth, receive additional public comments, and offer recommendations on the specifics of how a supplemental carbon tax should be enacted and applied.

Implementation Mechanisms

This option requires legislation and detailed tax collection system. Specifics of the implementation should be developed through an in-depth investigation as recommended under "Other" above.

Related Policies/Programs in Place

The RGGI C&T program and ES-3 are seen as complementary policies.

Type(s) of GHG Reductions

Reductions in emissions of CO_2 from combustion sources.

Estimated GHG Reductions and Net Costs or Cost Savings

As explained in more detail in the Annex, Maryland can meet its state goal by using only negative cost (cost saving) policies and measures. As a result, the incentives for additional GHG mitigation investments provided by a carbon tax are not needed to achieve the goal in principle, because it "pays" emitters to undertake reductions on their own. However, if there is concern about impediments to such voluntary action or if Maryland desired to achieve additional reductions over and above those required by the cap, and possibly through other policies capitalizing on the existence of zero or negative mitigation cost options, a carbon tax could be created offering the following costs and benefits.

Modeling indicates that for each dollar per ton of emissions from non-power sector sources in Maryland, approximately 75,000 tons of CO_2e will be mitigated. Assuming the state goal of 25% below 2006 emissions is achieved in 2020, this leaves 48.3 $MMtCO_2e$ being emitted from sectors other than the power sector. The implementation of the remaining (unused) negative cost mitigation options beyond the accomplishment of the state goal would reduce the emissions from the non-power sector further from 48.3 to 36.8 $MMtCO_2e$. Therefore, a $1 per ton carbon tax would "cost" $35.5 million (the emitters need to pay $1 tax per every ton of the remaining 36.8 $MMtCO_2e$ emissions) and yield 0.1 million tons of reduced emissions, for a cost per ton of $491. This does not take into consideration how the State of Maryland might apply the tax revenues to offset some of this cost.

Data Sources:

Emission projections data come from Center for Climate Strategies' inventory and forecast analysis of Maryland.

Reduction potentials and cost-effectiveness data of mitigation options of Maryland non-power sectors are used to develop the cost curves. This data is provided by other TWGs.

Quantification Methods:

The mitigation options list of the non-C&T sectors in Maryland are used in order to evaluate

- Whether the contributions of mitigation options from all the non-C&T sectors would meet the state goal;
- If not, what would be the carbon tax level to non-C&T sectors to achieve the goal; and
- If the mitigation options meet the state goal, how many incremental tons of CO_2 will be abated for each incremental dollar of carbon tax.

Some RCI sector options that completely or partially contribute to electricity consumption reduction are included in the options list to develop the Maryland power sector mitigation cost curve used in ES-3. To avoid double counting, the emissions mitigation potential related to electricity consumption reduction of those options are not included in the analysis here.

Key Uncertainties

We assume all the negative cost mitigations beyond the state goal would happen without any incentives from a carbon tax. Therefore, for the $1 carbon tax case, the non-power sectors would choose to pay the tax rather than mitigate those emissions that would have a unit reduction cost higher than $1 per ton. However, in practice, it is unclear how much the incentive (the tax rate) should be to encourage all the investments in negative cost opportunities.

Additional Benefits and Costs

The availability of $36.8 million in tax revenues per dollar of tax could provide Maryland with a range of additional benefits as a direct result of this policy. Investments in R&D that produce technological breakthroughs might not only produce greater and more cost-effective emissions reductions, but also pay dividends in the form of new jobs and economic growth.

Feasibility Issues

Any new tax, even if it is designed to be revenue neutral (revenues offset existing taxes), presents a substantial political challenge, especially in a tight economy. Also, at this point no U.S. state has enacted a carbon tax, so the effort necessary to convince affected groups would be greater than would be the case if there were favorable experience from another U.S. jurisdiction. Administration of the tax would not present particular challenges unless its design included classes of entities that have not previously been subject to similar taxes.

Status of Group Approval

This policy is a study product presented here for informational purposes.

Level of Group Support

Not applicable.

Barriers to Consensus

Not applicable.

ES-10. Generation Performance Standards (GPS)—1,125 Pounds Carbon Dioxide Equivalents per Megawatt-hour (CO_2e/MWh)

Policy Description

A GPS is a mandate that requires LSEs to acquire electricity on an average portfolio basis, with the portfolio meeting a per-unit emission rate below a specified standard. A GPS portfolio will incentivize investment in new low-carbon generation with overall lower GHG emissions in Maryland. A portfolio approach is a mechanism to control cost to the consumer as well, balancing the ES and environmental goals of the state.

The GPS will be modeled after the existing RPS program, with the exception the GPS may rely on a more diverse mix of replacements for coal power than the RPS. This will help encourage renewable energy sources and will also fit well with any state resource planning process for new generation.

The MWG recommends the enactment of a GPS with a standard of 1125 pounds of GHGs per megawatt-hour (MWh) by 2013.

Policy Design

Goals: The general goal of the policy is to encourage the purchase of energy and capacity from low-carbon or renewable technologies. In particular, the GPS portfolio would require that 100% of their energy portfolio emit an average of no more than a specified number of pounds of CO_2 per MWh. In response to suggestions made by the MWG, the analysis has been run using three potential GPS standards; 1050, 1100, and 1125 pounds per MWh. The GPS would be designed to harmonize with policies that seek to reduce GHG emissions by promoting greater use of renewable energy sources.

Timing: The program could be implemented by 2013, so as to provide time for new sources to be built.

Parties Involved: The program would apply to any LSE selling energy to retail consumers in the State of Maryland, competitive and those on Standard Offer Service. PSC would need to manage similar to the RPS obligation.

Other: Not applicable.

Implementation Mechanisms

Implementation would be through the PUC, which would develop a GPS program similar in design to the current RPS program to ensure compliance with the GPS.

Related Policies/Programs in Place

Under ES-7 the current RPS in place in Maryland would be strengthened. The GPS, as proposed here, would be applied separately from the RPS. In other words, the separate requirements of the two standards would not be additive. In addition, ES-8 (Energy Efficiency Improvements and

Repowering Coal Generation Plants) would complement this policy by reducing emissions from existing plants.

Type(s) of GHG Reductions

Reduces CO_2 emissions from fossil-fuel electric generators, and promotes low-carbon alternatives to fossil fuel generators.

Estimated GHG Reductions and Net Costs or Cost Savings

	Policy Option	GHG Reductions ($MMtCO_2e$)			Net Present Value 2008–2020 (Million $)	Cost-Effective-ness ($/t$CO_2$e)	Level of Support
		2012	2020	Total (2008–2020)			
ES-10	Generation Performance Standards (GPS)—1,125 Pounds of Carbon Dioxide Equivalents per Megawatt-Hour (CO_2e/MWh)	4.9	6.6	62.6	$2,659	$42.4	Unanimous

GHG = greenhouse gas; $MMtCO_2e$ = million metric tons of carbon dioxide equivalents; $/t$CO_2$e = dollars per ton of carbon dioxide equivalent.

This policy evaluates the net changes in GHG emissions as a result of the implementation of a GPS. The replacement energy alternatives are assumed to be apportioned similarly to the RPS, with greater reliance on lower-carbon sources than the RPS: NG, 40%; wind, 40%; landfill gas, 2%; biomass, 10%; and geothermal, 8%.

The 1,050 standard yielded 7.1 and 9.6 $MMtCO_2e$ reductions in 2012 and 2020, respectively, and 90.9 $MMtCO_2e$ cumulatively between 2008 and 2020.

The 1,100 standard yielded 5.7 and 7.6 $MMtCO_2e$ in 2012 and 2020, respectively, and 72.0 $MMtCO_2e$ cumulatively between 2008 and 2020.

The cost-effectiveness of each of these three standards is $42.4/tCO2e.

Data Sources:

- Emission projections data come from either CCS inventory and forecast studies of respective states, or publicly available data from EIA *Annual Energy Outlook 2007* for states lacking detailed "bottom up" assessments.
- R.S. Means. 2007. *Heavy Construction Cost Data*. Kingston, MA.
- EIA. 2007. *Assumptions for the Annual Energy Outlook 2007: with Projections to 2030*. Available at http://www.eia.doe.gov/oiaf/aeo/assumption/index.html
- MCCC. 2008. *Draft Straw Proposals of Policy Options*. Available at http://www.mdclimatechange.us/GHG_Carbon_Mitigation_WG.cfm
- Maryland PPRP. 2006. *The Potential for Biomass Co-firing in Maryland*. Available at http://esm.versar.com/PPRP/bibliography/PPES_06_02/PPES_06_02.pdf

Quantification Methods:

An analysis of the current electricity mix in Maryland indicates that the average energy intensity is about 1,290 pounds CO_2 per MWh. This policy quantifies the effect on GHG of implementing a GPS that stipulates the average emission rate for the entire energy portfolio (in-state and imports) be less than 1,050, 1,100 and 1,125 pounds of CO_2 per MWh. GHG emissions and costs from displaced coal were compared with emissions and costs from the mix of replacement power. The differences between these GHG emissions and costs are the net GHG reduction and net cost.

Key Assumptions:

This analysis does not consider the emissions associated with the marginal MWh from any one source type or location (i.e., electricity via a dedicated power line from West Virginia). Replacements of existing coal were assumed to be the fixed percentages discussed above. The GPS would be implemented at a rate of 20% per year, starting in 2009, with full implementation occurring in 2013. The GPS, as proposed here, would be applied separately from the RPS. In other words, the separate requirements of the two standards would not be additive.

Key Uncertainties

None.

Additional Benefits and Costs

Reduced air pollution; increased renewable power produced in Maryland.

Feasibility Issues

None.

Status of Group Approval

Approved.

Level of Group Support

Unanimous.

Barriers to Consensus

None.

Annex
Analysis of C&T Among Power Sectors of RGGI States and Carbon Tax in Maryland Non-C&T Sectors in 2020

A. Free Allocation of Allowances

The NLP Model used in the study is capable of analyzing various environmental policy instruments, including C&T, carbon taxes, and regulations, under a variety of conditions. For example, for C&T the model can analyze free granting vs. auctioning, upper limits on permit prices, offsets, banking, etc. In some cases, because of the extensive availability of low-cost mitigation options, the supply of allowances in C&T would exceed the demand for allowances at all positive allowance prices. Hence, trading would not be possible (a feasible solution for a positive allowance price that equalizes supply and demand of allowances in the market cannot be obtained from the model). Instead, two scenarios were analyzed with different assumptions for allowance price levels to resolve this problem. Then the supply and demand of allowances from each state, and the costs or savings of individual states before and after entering the C&T system were evaluated.

Example scenario: MC = Allowance Price = \$7/tCO_2

- According to the initial RGGI allowance allocation, Maryland, Maine, New Hampshire, Vermont, and Rhode Island do not have any GHG mitigation targets, since the allocated allowances to these states (see Column 3 of Table 1) exceed their 2020 BAU emission levels (see Column 2 of Table 1). For the remaining five states, which have binding mitigation goals, the reduction target (%) is computed in Column 4 of Table 1. Next, the reduction potential level was calculated in percentage terms at MC = \$7 (see Column 3 of Table 2). If this percentage is lower than the one shown in Column 4 in Table 1, the state would be a buyer of allowances. As shown in Column 4 of Table 2, Connecticut and New Jersey would be the buyers. In total, the allowances demand from these two states is 5.36 MMtCO_2. The allowance-selling states would be Delaware, Maryland, Maine, New Hampshire, New York, Vermont, Massachusetts, and Rhode Island.
- After achieving its own reduction target (41.94% below 2020 BAU level), the total allowances available for Delaware to sell with mitigation cost less than \$7 are 0.24 MMtCO_2. Assuming the remaining RGGI allowance demand (5.36 – 0.24 = 5.12 MMtCO_2) would be provided by the other 7 allowance selling states evenly, i.e., each of the selling states would sell 5.12/7 = 0.73 MMtCO_2 in the market.
- New York and Massachusetts do not have over-allocated allowances to sell. Therefore, they will provide all of the 0.73 MMtCO_2 allowances by autarkic (their own) mitigation actions with costs less than \$7/tCO_2 (after achieving their own state mitigation targets, these two states still have the capability to reduce emissions with cost less than \$7/tCO_2). Maryland, Maine, New Hampshire, Rhode Island, and Vermont will decide how much of the allowances they sell would come from autarkic mitigation actions and how much would come from the

excess allowances they possess. To gain the largest profit, these five states would choose to utilize all the cost-saving mitigation potentials inside the state first, since selling these allowances would bring them not only the cost-savings associated with the implementation of the mitigation options, but also the revenues from selling the allowances at the price of \$7/tCO_2. After exhausting cost-saving mitigation potentials, they will next choose to sell the excess allowances they hold, or undertake mitigation options with zero cost. They can sell these allowances without incurring any mitigation cost. After using up the excess allowances and zero cost options, these five states would be willing to sell those allowances they can achieve through autarkic mitigation actions with costs less than \$7/tCO_2.

The simulation results of the scenario with allowance price equal to \$7/tCO_2 are shown in Table 3. Simulation results of the scenario that assumes allowance price to be \$1/tCO_2 are presented in Table 4. In this case, Delaware would be the third buyer besides Connecticut and New Jersey, since the state autarkic mitigation potentials with MC less than \$1 fall short of meeting the state target (though Delaware's demand of allowance is very small [0.06 MMtCO_2e] compared with the other two buyers). Similar simulations were done with assumptions of allowance price at \$3/tCO_2 and \$5/tCO_2. These two cases yield similar simulation results as the \$7 case, with only Connecticut and New Jersey as the buyers. From the three cases with price at the levels of \$3, \$5, and \$7, the results show a negative relationship between the level of allowance price and the amount of allowances traded among the states. Approximately, allowance transactions are reduced 11 thousand tCO_2, with each increased dollar in the allowance price.

Table 1. RGGI States 2020 Emission Projections and Caps

	2020 BAU Emissions (MMtCO_2)	Cap/Budget (MMtCO_2)	Reduction Target (%)	Allowance Beyond BAU (MMtCO_2)	Reduction Target (MMtCO_2)
CT	13.26	9.09	31.45%	0.00	4.17
DE	11.07	6.43	41.94%	0.00	4.65
MD	31.79	31.88	0.00%	0.09	–0.09
ME	1.90	5.06	0.00%	3.15	–3.15
NH	4.93	7.33	0.00%	2.40	–2.40
NJ	23.40	19.46	16.86%	0.00	3.95
NY	56.11	54.66	2.58%	0.00	1.45
VT	0.03	1.04	0.00%	1.01	–1.01
MA	24.97	22.66	9.26%	0.00	2.31
RI	1.78	2.26	0.00%	0.48	–0.48
Total	**169.26**	**159.87**	**5.55%**	**7.13**	**9.39**

BAU = business as usual; MMtCO_2 = million metric tons of carbon dioxide.

*The shaded states, Maryland, Maine, New Hampshire, Vermont, and Rhode Island, have allocated allowances higher than their projected 2020 BAU emission levels. As a result, these states have zero emission reduction targets in their power sector. In addition, they can sell the excess allowances in the market at zero mitigation cost.

Sources: 1. RGGI States GHG Caps by Year from 2009 to 2018 are provided by Jeff Wennberg from CCS. Numbers for 2019 and 2020 are estimated by extrapolating 2014 to 2018 numbers.

2. RGGI states 2020 BAU emission projections are obtained from RGGI Web site http://www.rggi.org/documents.htm, the Reference Case projections. The 2020 values are computed by interpolating 2018 and 2021 projections.

Table 2. Determination of Allowances Purchasing and Selling States

	Reduction Target (%)	In-state Reduction Potential with MC<= $7 (%)	Whether an Allowance Buyer	Amount of Allowances to Buy
CT	31.45%	5.78%	Yes	3.40
DE	41.94%	44.17%	No	
MD	0.00%	53.34%	No	
ME	0.00%	39.92%	No	
NH	0.00%	6.78%	No	
NJ	16.86%	8.49%	Yes	1.96
NY	2.58%	5.44%	No	
VT	0.00%	100.00%	No	
MA	9.26%	47.72%	No	
RI	0.00%	62.95%	No	
Total	**5.55%**	**24.71%**	**—**	**5.36**

MC= marginal cost; **MC<= $7 (%) = percentage reduction potential with marginal cost less than, or equal to, seven dollars.**

Note: If the percentage in the third column is less than the reduction target, in percentage terms, in the second column, the state would be an allowance buyer.

Table 3. Power sector C&T simulation among 10 RGGI states in Year 2020 Scenario 1: allowance price = $7/t$CO_2$ (million dollars or otherwise specified)

	Before Trading	After Trading				Allowances Traded	Emission Reduction with Trading		Emission Reduction Goal
State	Mitigation Cost	Mitigation Cost	Trading Cost	Net Cost	Cost Saving	(million tCO_2)	(million tCO_2)	(percent from BAU)	(percent from BAU)
CT	1,200.05	–49.64	23.83	–25.81	1,225.86	3.40	0.77	5.78	31.45
DE	–165.12	–164.01	–1.70	–165.71	0.59	–0.24	4.89	44.17	41.94
MD	0.00	–44.41	–5.12	–49.53	49.53	–0.73	0.64	2.02	0.00
ME	0.00	–41.49	–5.12	–46.61	46.61	–0.73	0.72	38.00	0.00
NH	0.00	–25.72	–5.12	–30.84	30.84	–0.73	0.32	6.50	0.00
NJ	38.45	–313.93	13.71	–300.22	338.67	1.96	1.99	8.49	16.86
NY	–418.66	–530.22	–5.12	–535.14	116.49	–0.73	2.18	3.88	2.58
VT	0.00	–2.34	–5.12	–7.47	7.47	–0.73	0.03	100.00	0.00
MA	–235.68	–301.51	–5.12	–306.63	70.95	–0.73	3.04	12.19	9.26
RI	0.00	–61.48	–5.12	–66.60	66.60	–0.73	1.07	60.45	0.00
Total	**419.04**	**–1,534.55**	**0.00**	**–1,534.55**	**1,953.59**	**5.36***	**15.66**	**9.25**	**9.76**

tCO_2 = tons of carbon dioxide; BAU = business as usual.

*Represents number of allowances bought or sold.

Table 4. Power sector C&T simulation among 10 RGGI states in Year 2020
Scenario 2: allowance price = $1/$tCO_2$ (million dollars or otherwise specified)

	Before Trading	After Trading				Allowances Traded	Emission Reduction with Trading		Emission Reduction Goal
State	Mitigation Cost	Mitigation Cost	Trading Cost	Net Cost	Cost Saving	(million tCO_2)	(million tCO_2)	(percent from BAU)	(percent from BAU)
CT	1,200.05	–49.77	3.44	–46.33	1,246.38	3.44	0.73	5.54	31.45
DE	–165.12	–165.20	0.06	–165.15	0.02	0.06	4.59	41.46	41.94
MD	0.00	–47.96	–0.78	–48.75	48.75	–0.78	0.69	2.19	0.00
ME	0.00	–41.49	–0.78	–42.27	42.27	–0.78	0.72	38.00	0.00
NH	0.00	–25.72	–0.78	–26.50	26.50	–0.78	0.32	6.50	0.00
NJ	38.45	–314.07	1.99	–312.07	350.52	1.99	1.95	8.34	16.86
NY	–418.66	–535.37	–0.78	–536.15	117.49	–0.78	2.23	3.98	2.58
VT	0.00	–2.34	–0.78	–3.13	3.13	–0.78	0.03	100.00	0.00
MA	–235.68	–306.05	–0.78	–306.83	71.15	–0.78	3.10	12.40	9.26
RI	0.00	–61.48	–0.78	–62.26	62.26	–0.78	1.07	60.45	0.00
Total	**419.04**	**–1,549.45**	**0.00**	**–1,549.45**	**1,968.48**	**5.49***	**15.45**	**9.13**	**9.76**

tCO_2 = tons of carbon dioxide; BAU = business as usual.

*Represents number of allowances bought or sold.

B. Auction of Allowances

In the case where allowances are auctioned, the 2020 emission caps for Connecticut, Delaware, New Jersey, New York, and Massachusetts were assumed to be the same as in the free granting case. For Maryland, Maine, New Hampshire, Vermont, and Rhode Island, which have excess allowances in the free granting case, it was assumed their caps in the auction case would equal the state BAU 2020 emission levels (i.e., there is no reason to purchase any excess allowances at auction). Table 5 shows the emission caps for the 10 RGGI states in the auction case.

Table 5. RGGI States 2020 Emission Projections and Caps (Auction Case)

	2020 BAU Emissions ($MMtCO_2$)	Cap/Budget ($MMtCO_2$)
CT	13.26	9.09
DE	11.07	6.43
MD	31.79	31.79
ME	1.90	1.90
NH	4.93	4.93
NJ	23.40	19.46
NY	56.11	54.66
VT	0.03	0.03
MA	24.97	22.66
RI	1.78	1.78
Total	**169.26**	**152.82**

BAU = business as usual; $MMtCO_2$ = million metric tons of carbon dioxide.

In the auction case, there would be no trading among states. According to the basic rationale for permit trading, in equilibrium, each state would choose to mitigate emissions, as long as its marginal abatement cost is lower than or equal to the price of allowances, and purchase the remaining allowance (the difference between the state's BAU level and the amount mitigated by autarkic actions) from the auctioneer. Table 6 presents the amount of emissions that can be reduced by each state's autarkic mitigation actions associated with MC of $7/$tCO_2e$. The simulation results of the auction case with allowance price equal to $7/$tCO_2e$ are presented in Table 7. A second simulation with the auction price assumed to be at $1/$tCO_2e$ is presented in Table 8.

In usual C&T cases, where the equilibrium point corresponds to a positive allowance price, auction and free granting would reach the same cost-effectiveness level, i.e., the auction price would be at the same level as the equilibrium price in the allowance trading market, and the collaborative CO_2 reductions achieved by the partner states in these two allocation cases would be the same and equal to the overall emission reduction target of the region. The only difference between these two allocation cases would be that the auction can generate revenues to the state government, which in turn can be recycled to fund R&D in such innovations as clean energy technologies and end-use energy efficiencies, and thus, lower the impacts to the electricity ratepayers.

However, as indicated in Section A, the supply would exceed the demand at all positive allowance prices in RGGI's case. Therefore, in the case of C&T with a grandfathering allocation strategy and with the assumed market price at $7/$tCO_2$, to ensure the balance of trade in the market (supply equalizing demand), many states (e.g., Maryland, New York, Massachusetts) would not use up all their mitigation potentials with MC less than $7/$tCO_2$. Collaboratively, the emission reductions achieved by the 10 states in the free granting case with allowance price equal to $7/$tCO_2$ are 15.66 $MMtCO_2$. Beyond C&T, a state would still be willing to mitigate any ton of GHG that would bring net cost savings. The additional cost-saving mitigation potential for the 10 states beyond C&T (free granting case) is 24.00 $MMtCO_2$. In the auction case, each state would utilize all its mitigation potential with MC less than $7/$tCO_2$ before purchasing allowances from the auctioneer. As a result, the total emission reductions achieved by the 10 states in this case are 41.82 $MMtCO_2$. Since considerable amounts of unused mitigation potentials of some states (e.g., Maryland, Massachusetts) in the free granting case are associated with cost savings, the total cost savings of mitigation in the auction case (2.54 billion) are higher than the total mitigation cost savings in the free granting case (1.53 billion). In addition, in the auction case many states would reduce more emissions than required by the state mitigation target (because it is cheaper to mitigate than to buy from the auctioneer). The additional reductions achieved by these states can be saved for future use.

Comparing the two auction cases with auction prices at $7 and $1, the amount the states choose to reduce by mitigation options (41.82 $MMtCO_2$ vs. 39.98 $MMtCO_2$) and the amount to be bought from the auctioneer (127.44 $MMtCO_2$ vs. 129.28 $MMtCO_2$) differ slightly. The big difference in total auction cost between these two cases is due primarily to the difference of the two auction price levels.

Table 6. Mitigation potential associated with MC = $7/$tCO_2e$

	Cap/Budget ($MMtCO_2$)	In-state Reduction Potential with MC<= $7 (%)	In-state Reduction Potential with MC<= $7 ($MMtCO_2$)
CT	9.09	5.78%	0.77
DE	6.43	44.17%	4.89
MD	31.88	53.34%	16.96
ME	1.90	39.92%	0.76
NH	4.93	6.78%	0.33
NJ	19.46	8.49%	1.99
NY	54.66	5.44%	3.05
VT	0.03	100.00%	0.03
MA	22.66	47.72%	11.92
RI	1.78	62.95%	1.12
Total	**152.82**	**24.71%**	**41.82**

$MMtCO_2$ = million metric tons of carbon dioxide; MC<= $7 = marginal cost is less than or equal to seven dollars.

Table 7. Simulation results of an auction case among RGGI states (with assumed auction price at $7/tCO_2$)

State	Total BAU Emissions in 2020 (million tCO_2)	2020 Emissions Cap/Budget (million tCO_2)	Emission Reduction Undertaken by the State*		Mitigation Cost (million $)	Emission Allowances Bought from Auctioneer (million tCO_2)	Auction Cost (million $)†	Net Cost (million $)‡
			(percent from BAU)	(million tCO_2)				
CT	13.26	9.09	5.78	0.77	–49.64	12.50	87.47	37.83
DE	11.07	6.43	44.17	4.89	–164.01	6.18	43.28	–120.73
MD	31.79	31.88	53.34	16.96	–617.74	14.83	103.83	–513.91
ME	1.90	1.90	39.92	0.76	–41.36	1.14	8.00	–33.36
NH	4.93	4.93	6.78	0.33	–25.67	4.59	32.16	6.48
NJ	23.40	19.46	8.49	1.99	–313.93	21.42	149.92	–164.01
NY	56.11	54.66	5.44	3.05	–573.12	53.06	371.43	–201.69
VT	0.03	0.03	100.00	0.03	–2.34	0.00	0.00	–2.34
MA	24.97	22.66	47.72	11.92	–692.28	13.06	91.40	–600.88
RI	1.78	1.78	62.95	1.12	–61.32	0.66	4.61	–56.71
Total	**169.26**	**152.82**	**24.71**	**41.82**	**–2,541.43**	**127.44**	**892.09**	**–1,649.33**

BAU = business as usual; tCO_2 = tons of carbon dioxide.

* In equilibrium, each state will choose to mitigate to the level that its marginal abatement cost equals the auction price.

† We assume the auction price is $7/tCO_2$ in this case.

‡ Sum of mitigation cost and auction cost.

Table 8. Simulation results of an auction case among RGGI states (with assumed auction price at $1/tCO_2$)

State	Total BAU Emissions in 2020 (million tCO_2)	2020 Emissions Cap/Budget (million tCO_2)	Emission Reduction Undertaken by the State*		Mitigation Cost (million $)	Emission Allowances Bought from Auctioneer (million tCO_2)	Auction Cost (million $)†	Net Cost (million $)‡
			(percent from BAU)	(million tCO_2)				
CT	13.26	9.09	5.54	0.73	–$49.77	12.53	$12.53	–$37.24
DE	11.07	6.43	41.46	4.59	–$165.20	6.48	$6.48	–$158.72
MD	31.79	31.88	50.49	16.05	–$620.34	15.74	$15.74	–$605.60
ME	1.90	1.90	38.28	0.73	–$41.49	1.17	$1.17	–$40.31
NH	4.93	4.93	6.54	0.32	–$25.72	4.61	$4.61	–$21.11
NJ	23.40	19.46	8.34	1.95	–$314.07	21.45	$21.45	–$292.62
NY	56.11	54.66	5.35	3.00	–$573.31	53.11	$53.11	–$520.20
VT	0.03	0.03	100.00	0.03	–$2.34	0.00	$0.00	–$2.34
MA	24.97	22.66	45.96	11.48	–$694.03	13.50	$13.50	–$680.54
RI	1.78	1.78	60.81	1.08	–$61.47	0.70	$0.70	–$60.78
Total	**169.26**	**152.82**	**23.62**	**39.98**	**–$2,548.74**	**129.28**	**$129.28**	**–$2,419.46**

BAU = business as usual; tCO_2 = metric tons of carbon dioxide.

* In equilibrium, each state will choose to mitigate to the level that its marginal abatement cost equals the auction price.

† In this case, it is assumed that the auction price is $1/tCO_2$.

‡ Sum of mitigation cost and auction cost.

Development of the Marginal Cost Curves of Power Sector

The MC curves of the states are developed based on the reduction potential and mitigation cost/saving data of individual options that contribute to the emission reductions from power sector. These options not only include those designed directly for the electricity supply sector (e.g., promotion of renewable energy utilization, repowering existing plants, GPS), but also include options in RCI sectors that contribute to the reduction of electricity consumption (e.g., DSM, energy efficient appliances, building codes). The emission reduction potentials of these options are adjusted by multiplying the percentage of electricity consumption to total energy consumption in the RCI sector. RCI options that relate entirely to reduction of other fossil fuels consumption (e.g., gas, oil) are not included in the cost curve development. Table 9 presents the list of options of Maryland used to develop the MC curve of the state.

Table 9. Maryland Mitigation options list to develop the MC curve of power sector

Sector	Climate Mitigation Actions	Estimated 2020 Annual GHG Reduction Potential ($MMtCO_2e$)	Estimated Cost or Cost Savings per ton GHG Removed	GHG Reduction Potential as Percentage of 2020 Baseline Emissions*	Cumulative GHG Reduction Potential	Weights (add up to 100)
RCI-7	More Stringent Appliance / Equipment Efficiency Standards (State-Level, or Advocate for Regional- or Federal-Level Standards)	0.14	–$54.00	0.42%	0.42%	0.329
RCI-4	Improved Design, Construction, Appliances, and Lighting in New and Existing State and Local Government Buildings, “Government Lead-By-Example”	0.89	–$53.00	2.80%	3.22%	2.167
RCI-10	Energy Efficiency Resource Standard (EERS)	8.04	–$52.00	25.28%	28.50%	19.592
RCI-2	Demand-Side Management (DSM) / Energy Efficiency Programs, Funds, or Goals for Electricity (Including Expansion of Existing Programs and Peak Load Reduction)	3.70	–$51.00	11.64%	40.14%	9.021
RCI-11	Promotion and Incentives for Energy-Efficient Lighting	1.10	–$47.00	3.46%	43.60%	2.682
RCI-3	Low-Cost Loans for Energy Efficiency	0.35	–$45.00	1.09%	44.69%	0.847
RCI-1	Improved Building and Trade Codes and Beyond-Code Building Design and Construction	1.67	–$38.00	5.25%	49.94%	4.067
ES-5b	Clean Distributed Generation (DG): Combined Heat and Power (CHP)	1.00	$14.40	3.15%	53.08%	2.438
ES-8a	Efficiency Improvements and Repowering Existing Plants—Distributed Generation (DG)	2.00	$21.80	6.29%	59.37%	4.876
ES-7	Renewable or Environmental Portfolio Standard (e.g., Add CHP or EE To RPS as Additional Tier) or Energy Efficiency Portfolio Standard	13.80	$25.70	43.41%	102.79%	33.647
ES-1	Promotion of Renewable Energy (Zoning, Siting, Incentives for Centralized Facilities, Long-Term Contracting, Performance-Based Contracting)	0.50	$27.00	1.57%	104.36%	1.219
ES-5a	Clean Distributed Generation (DG): Distributed Generation	1.10	$37.50	3.46%	107.82%	2.682

Sector	Climate Mitigation Actions	Estimated 2020 Annual GHG Reduction Potential ($MMtCO_2e$)	Estimated Cost or Cost Savings per ton GHG Removed	GHG Reduction Potential as Percentage of 2020 Baseline Emissions*	Cumulative GHG Reduction Potential	Weights (add up to 100)
ES-10	Generation Performance Standards (GPS)—1,125 Pounds Carbon Dioxide Equivalents per Megawatt-Hour (Co_2e/MWh)	6.60	$42.40	20.76%	128.58%	16.092
RCI-8	Rate Structures and Technologies to Promote Reduced Greenhouse Gas (GHG) Emissions (Including Peak Pricing and Inverted Block Rates)	0.14	$120.00	0.44%	129.02%	0.339

GHG = greenhouse gas; $MMtCO_2e$ = million metric tons of carbon dioxide equivalents; EE = energy efficiency; RPS = renewable portfolio standard; CCSR = combined capture, storage, and reuse.

* 2020 projected production-based gross emission level is 31.79 $MMtCO_2e$.

In Table 9, Column 3 presents the estimated 2020 annual GHG reduction potential for each relevant option, with reduction potentials translated into percentages of the 2020 ES BAU emissions level in Column 5. The estimated cost or cost saving per ton of GHG removed by each option in 2020 is presented in Column 4. The options are ordered in ascending sequence in terms of cost, beginning with the cheapest option. Column 6 calculates the cumulative GHG reduction potentials of the first *n* policy options listed in the table. The last column presents the proportion of GHG mitigation contributed by each option.

Based on the data presented in Table 9, the stepwise MC function for Maryland in 2020 is drawn in Figure 1. The horizontal axis represents the percentage of GHG emissions reduction, and the vertical axis represents the MC or savings of mitigation. In the figure, each horizontal segment represents an individual mitigation option. The width of the segment indicates the GHG emission reduction potential of the option in percentage terms. The height of the segment relative to the x-axis shows the average cost (saving) of reducing 1 ton of GHG with the application of the option.

Next, the following functional form was used to fit the smooth Maryland MC curve to be used in our analysis:

$$MC = a + b \times \ln(1 - R)$$

Where, *MC* is the marginal cost; *R* is the percentage reduction of GHG emissions; *a* and *b* are parameters.

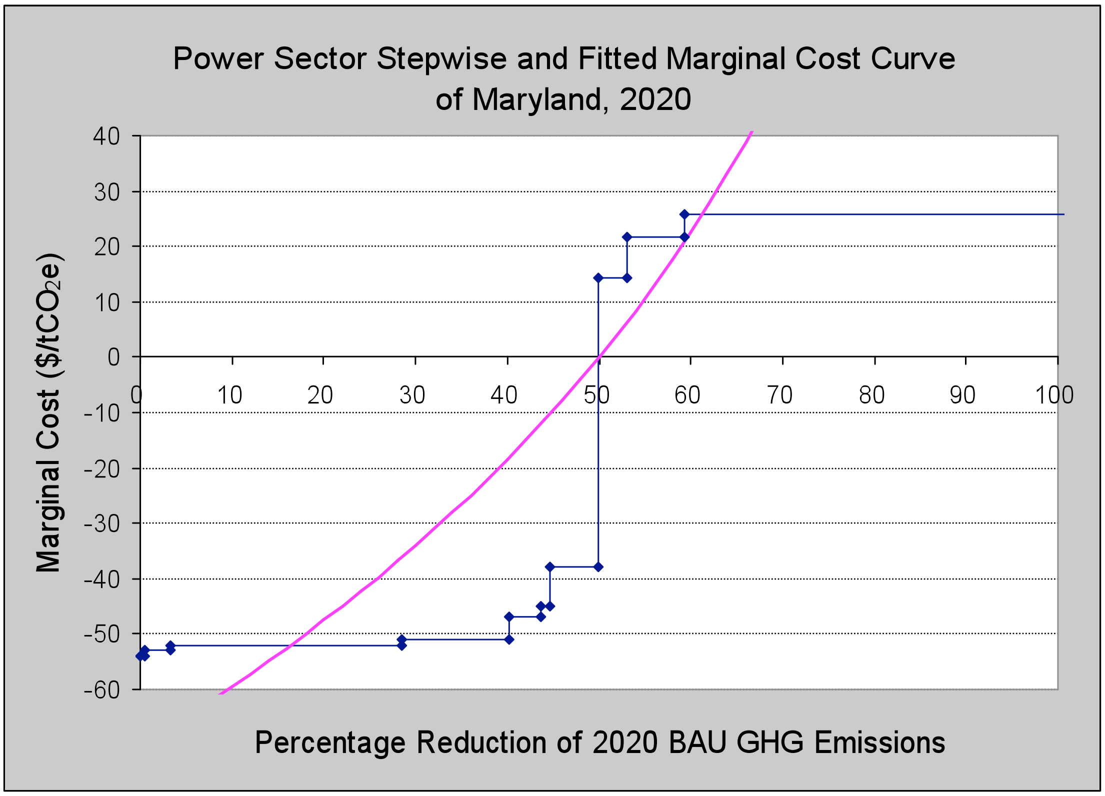
The logarithmic functional form utilized here is consistent with theoretical expectations and empirical findings on diminishing returns of emission control. As the emission reductions increase along the x-axis, the cost to reduce one additional unit of emission is increasing at an accelerating speed.

To develop the fitted cost curve, it is forced to cross the x-axis through the point of 50%, the same x-intercept indicated by the step function. The MC curve of Maryland has the following specification:

$$MC = -70.15 - 101.21 \times \ln(1 - R)$$

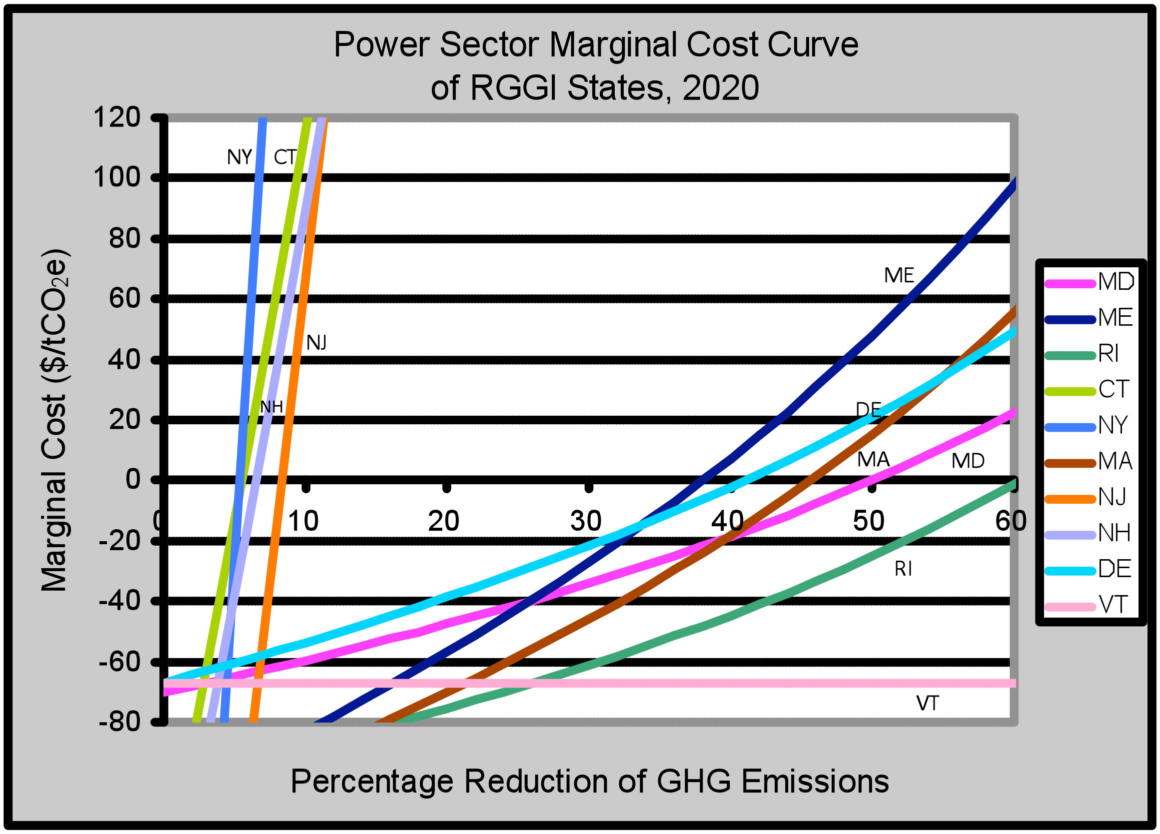
Figure 1 shows the step and fitted MC curves of the Maryland power sector.

Figure 1. MC curves of Maryland power sector



$\$/tCO_2e$ = dollars per metric ton of carbon dioxide equivalent; BAU = business as usual; GHG = greenhouse gas.

Figure 2. State MC curves of power sector, 2020



$/tCO$_2$e = dollars per metric ton of carbon dioxide equivalent; RGGI = Regional Greenhouse Gas Initiative; GHG = greenhouse gas; MD = Maryland; ME = Maine; RI = Rhode Island; CT = Connecticut; NY = New York; MA = Massachusetts; NJ = New Jersey; NH = New Hampshire; DE = Delaware; VT = Vermont.

Notes: Similar methods as elaborated above for Maryland are adopted to develop MC curves of Connecticut, Maine, New York, Rhode Island, and Vermont. Data sources are listed below.

There are no direct data for Massachusetts, New Jersey, New Hampshire, and Delaware. MC curves for these four states are developed based on cost curves of four reference states (Rhode Island, New York, Connecticut, and Maryland, respectively). For each of the four states that lack the direct data, mitigation cost/saving data for the reference state is adopted. Emission reduction potential data of the reference state is adjusted by the weights of emissions from the ES and RCI sectors of the state under estimation.

Sources:

- Connecticut GSC on Climate Change. 2005. *2005 CT Climate Change Action Plan*. Available at http://www.ctclimatechange.com/StateActionPlan.html
- MCCC. 2008. Maryland Climate Change Action Plan. Available at http://www.mdclimatechange.us/index.cfm
- Maine DEP. 2004. Final Maine Climate Action Plan 2004. Available at http://www.maine.gov/dep/air/greenhouse/
- CCAP and New York GHG Task Force. 2003. *Recommendations to Governor Pataki for Reducing New York State Greenhouse Gas Emissions*. Available at http://www.ccap.org/pdf/04-2003_NYGHG_Recommendations.pdf
- RI GHG. 2002. *Rhode Island Greenhouse Gas Action Plan*. Available at http://righg.raabassociates.org/.
- Vermont GCCC. 2007. *Final Report and Recommendations of the Governor's Commission on Climate Change*. Available at http://www.anr.state.vt.us/air/Planning/htm/ClimateChange.htm.

C. Carbon Tax

In this simulation, the level of carbon tax to the non-C&T sectors will be estimated to yield the Maryland state reduction target in year 2020—25% below 2006 levels.

Table 10. Emission reduction target by sector to achieve the Maryland state goal

	2006 ($MMtCO_2$)	2020 ($MMtCO_2$)	Emission Cap in 2020 (25% below 2006) ($MMtCO_2$)	Emission Reduction Target ($MMtCO_2$)	Emission Reduction Target Percentage
Emissions from electricity—production based	32.2	31.8	24.1	7.7	24.1%
Emissions from electricity—consumption based	42.7	53.4	32.1	21.4	40.0%
Emissions from non-electricity sector	64.4	76.7	48.3	28.4	37.0%
Total gross emissions (consumption based)	107.2	130.2	80.4	49.8	38.2%

$MMtCO_2$ = million metric tons of carbon dioxide.

According to the analyses in Sections A and B, the power sector in Maryland can reach the state mitigation goal by implementing in-state policies and measures affecting the power sector and by purchasing allowances from the RGGI C&T system. The power sector would implement in-state mitigation options, as long as the marginal abatement cost is less than or equal to the price of the allowance, and purchase the remaining allowances from power sector in other states (in the free granting case) or the auctioneer (in the auction case).

Next, one needs to look at the mitigation options list of the non-C&T sectors in Maryland in order to evaluate:

- Whether the contributions of mitigation options from all the non-C&T sectors would meet the state goal;
- If not, what would be the carbon tax level to non-C&T sectors to achieve the goal; and
- If the mitigation options meet the state goal, how many incremental tons of CO_2 will be abated for each increasing dollar of carbon tax.

Table 11 shows the options list of non-C&T sectors in Maryland. Note that some RCI sector options that entirely or partially contribute to electricity consumption reduction are included in the options list to develop the Maryland power-sector mitigation cost curve in Figure 1. To avoid double counting, the part of emission mitigation potentials related to electricity consumption reduction of those options is not included in the list in Table 11. Please also note that only options with quantified reduction potentials and costs/savings estimated by the TWGs are included in Table 11. Similar to Table 9, Column 3 of the table presents the estimated 2020 annual GHG reduction potential for each option, with reduction potentials translated into percentages of the 2020 BAU emissions level in Column 5. The estimated cost or cost saving per ton of GHG removed by each option in 2020 is presented in Column 4. The options are ordered in ascending sequence in terms of cost, beginning with the cheapest option. Column 6 calculates the cumulative GHG reduction potentials of the first *n* policy options listed in the table. The last column presents the proportion of GHG mitigation contributed by each option.

Table 11. Mitigation options list of non-C&T sectors in Maryland

Sector	Climate Mitigation Actions	Estimated 2020 Annual GHG Reduction Potential ($MMtCO_2e$)	Estimated Cost or Cost Savings per Ton GHG Removed	GHG Reduction Potential as Percentage of 2020 Baseline Emissions†	Cumulative GHG Reduction Potential
AFW-5	"Buy Local" Programs for Sustainable Agriculture, Wood, and Wood Products—a. Farmer's Market	0.03	–$167.00	0.04%	0.04%
AFW-2	Managing Urban Trees and Forests for Greenhouse Gas (GHG) Benefits (With Mitigation of Forest Loss Due to Insects, Disease, Pests, and Invasive Species)	1.90	–$152.00	2.48%	2.52%
RCI-7	More Stringent Appliance / Equipment Efficiency Standards (State-Level, or Advocate for Regional- or Federal-Level Standards)	0.06	–$54.00	0.08%	2.60%
RCI-4	Improved Design, Construction, Appliances, and Lighting in New and Existing State and Local Government Buildings, "Government Lead-by-Example"	0.41	–$53.00	0.54%	3.14%
RCI-10	Energy Efficiency Resource Standard (EERS)	3.86	–$52.00	5.04%	8.18%
RCI-3	Low-Cost Loans for Energy Efficiency	0.15	–$45.00	0.20%	8.37%
RCI-1	Improved Building and Trade Codes and Beyond-Code Building Design and Construction	0.73	–$38.00	0.95%	9.33%
AFW-8	Nutrient Trading With Carbon Benefits	0.14	$30.00	0.18%	9.51%
AFW-9	Waste Management Through Source Reduction and Advanced Recycling	29.20	–$6.00	38.06%	47.57%
AFW-6	Expanded Use of Forest and Farm Feedstocks and By-Products for Energy Production—Methane (CH_4) Utilization From Livestock Manure and Poultry Litter	0.04	$0.20	0.05%	47.62%
AFW-7	In-State Liquid Biofuels Production—Bio-diesel	0.17	$7.00	0.22%	47.84%
AFW-6	Expanded Use of Forest and Farm Feedstocks and By-Products for Energy Production—Biomass (Including Agriculture Residue, Forest Feedstocks, and Energy Crops)	0.50	$12.00	0.65%	48.29%
AFW-3	Afforestation, Reforestation, and Restoration of Forests and Wetlands—	0.60	$29.00	0.78%	49.28%

Sector	Climate Mitigation Actions	Estimated 2020 Annual GHG Reduction Potential ($MMtCO_2e$)	Estimated Cost or Cost Savings per Ton GHG Removed	GHG Reduction Potential as Percentage of 2020 Baseline Emissions†	Cumulative GHG Reduction Potential
	a. Afforestation				
AFW-4	Forested Land— b. Forested Land	2.70	$37.00	3.52%	52.79%
AFW-3	Afforestation, Reforestation, and Restoration of Forests and Wetlands— b. Riparian Areas	0.05	$44.00	0.07%	52.86%
TLU-4*	Low Greenhouse Gas Fuel Standard (LGFS)	1.90	$60.00	2.48%	55.34%
AFW-7	In-State Liquid Biofuels Production—Ethanol	0.91	$80.00	1.19%	56.52%
AFW-4	Forested Land— a. Agricultural Land	0.28	$87.00	0.36%	56.89%
RCI-8	Rate Structures and Technologies To Promote Reduced GHG Emissions (Including Inverted Block Rates)	0.06	$120.00	0.08%	56.97%
AFW-1	Forest Management for Enhanced Carbon Sequestration (With Mitigation of Forest Loss Due to Insects, Disease, Pests, and Invasive Species)	0.09	$135.00	0.12%	57.08%
TLU-10*	Transportation Technologies	0.44	$650.00	0.57%	57.66%

GHG = greenhouse gas; $MMtCO_2e$ = million metric tons of carbon dioxide equivalents.

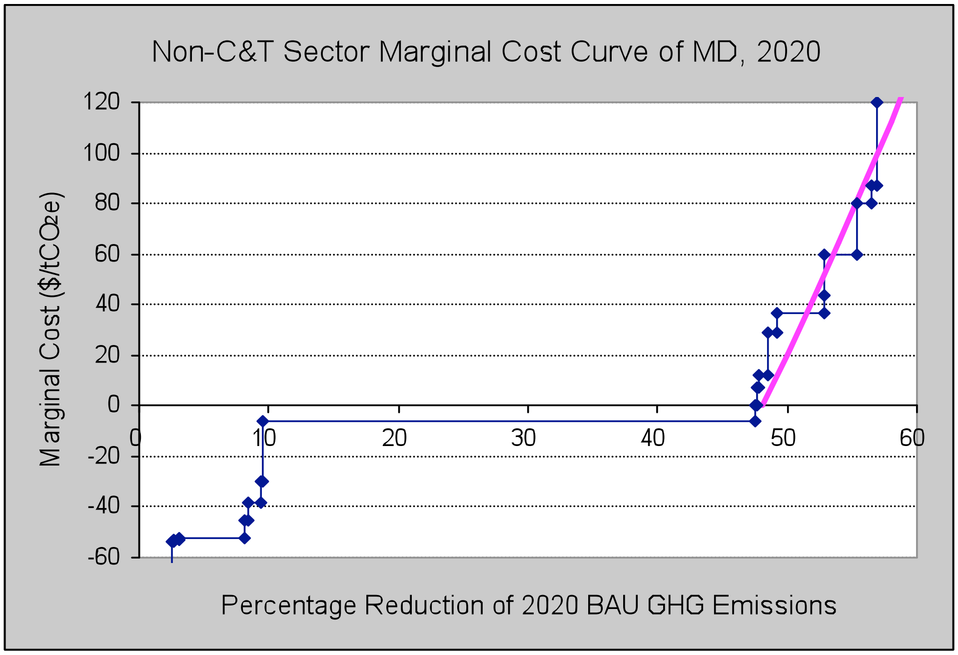
* Numbers presented in the column of "Estimated Cost or Cost Savings per Ton GHG Removed" are the average of the high and low estimates by the TLU TWG.

† 2020 projected gross CO_2 emissions from non-C&T sectors are 76.92 $MMtCO_2e$.

From Column 6 of Table 11, the cumulative mitigation potential of options with cost savings is around 47.57% of the non-C&T sectors' 2020 BAU emissions level. As shown in Table 10, the reduction goal of 25% below the 2006 level translates to 37.0% below 2020 BAU level for the non-C&T sectors. Therefore, the state goal can be over-achieved by implementing only the cost-saving mitigation options.

Thus, to achieve current 2020 goal, the carbon tax is not needed. However, one can examine the potential of a carbon tax for additional mitigation in the following way. Fit a smooth curve through the points of options with unit mitigation cost higher than zero (see the smooth curve in Figure 3). Based on the curve, Table 12 presents the total reduction potentials of the non-C&T sectors with assumed carbon tax levels at $1 to $7. Approximately, for every $1 increase in the carbon tax, an additional 75 thousand tons of CO_2 will be abated in the non-C&T sectors.

Figure 3. MC curve of non-C&T sectors in Maryland



$/$tCO_2$e = dollars per metric ton of carbon dioxide equivalent C&T = cap-and-trade; MD = Maryland; BAU = business as usual; GHG = greenhouse gas.

Note: The step curve is developed based on the options data in Table 11. The horizontal axis represents the percentage of GHG emissions reduction, and the vertical axis represents the MC or savings of mitigation. In the figure, each horizontal segment represents an individual mitigation option. The width of the segment indicates the GHG emission reduction potential of the option in percentage terms. The height of the segment relative to the x-axis shows the average cost (saving) of reducing 1 ton of GHG with the application of the option. The smooth curve is fitted through the points of options with unit mitigation cost higher than zero.

Table 12. Carbon tax level and corresponding total reduction potential in non-C&T sectors

Carbon Tax ($/$tCO_2$)	Total Reduction Potential		Incremental Reduction per Dollar Increase in the Carbon Tax (thousand tCO_2)
	% 2020 BAU level	$MMtCO_2$	
0	48.02%	36.84	
1	48.12%	36.92	75.57
2	48.22%	36.99	75.43
3	48.31%	37.07	75.28
4	48.41%	37.15	75.14
5	48.51%	37.22	75.00
6	48.61%	37.29	74.86
7	48.70%	37.37	74.71

$/$tCO_2$ = dollars per ton of carbon dioxide; BAU = business as usual; $MMtCO_2$ = million metric tons of carbon dioxide.

Maryland Climate Action Plan

Appendix D-3

Residential, Commercial & Industrial

Residential, Commercial, and Industrial Sector

Summary List of Recommended Priority Policy Options for Analysis

Option No.	Policy Option	GHG Reductions ($MMtCO_2e$)			Net Present Value 2008–2020 (Million $)	Cost-Effectiveness ($/$tCO_2e$)	Level of Support
		2012	2020	Total 2008–2020			
RCI-1	Improved Building and Trade Codes and Beyond-Code Building Design and Construction in the Private Sector	0.6	2.4	13.8	–$527	–$38	Unanimous
RCI-2	Demand-Side Management (DSM) / Energy Efficiency Programs, Funds, or Goals for Electricity and Natural Gas (Including Expansion of Existing Programs and Peak Load Reduction)	1.8	4.5	35.0	–$1,898	–$54	Unanimous
RCI-3	Low-Cost Loans for Energy Efficiency	0.3	0.5	4.1	–$187	–$45	Unanimous
RCI-4	Improved Design, Construction, Appliances, and Lighting in New and Existing State and Local Government Buildings, Facilities and Operations: "Government Lead-by-Example"	0.2	1.3	6.4	–$337	–$53	Unanimous
RCI-5	Energy Efficiency and Environmental Impacts Awareness and Instruction in School Curricula	*Jointly considered with the CC TWG*					Unanimous
RCI-6	Promotion and Incentives for Improved Design and Construction (e.g., LEED™, Green Buildings, or Minimum Percent Improvement Better Than Code) in the Private Sector	*Combined with RCI-1*					
RCI-7	More Stringent Appliance / Equipment Efficiency Standards (State-Level, or Advocate for Regional- or Federal-Level Standards)	0.1	0.2	1.2	–$63	–$54	Unanimous
RCI-8	Rate Structures and Technologies To Promote Reduced GHG Emissions (Including Peak Pricing and Inverted Block Rates)	0.1	0.2	2.0	$246	$120	Unanimous
RCI-9	GHG or Carbon Tax	*Transferred to ES TWG*					
RCI-10	Energy Efficiency Resource Standard (EERS)	2.9	11.9	71.0	–$3,670	–$52	Unanimous
RCI-11	Promotion and Incentives for Energy Efficient Lighting	0.1	1.1	7.7	–$362	–$47	Unanimous
	Sector Total After Adjusting for Overlaps*	**1.1**	**11.2**	**54.1**	**–$5,450**	**–$48**	
	Reductions From Recent Actions†	**4.3**	**9.0**	**71.5**	**Not quantified**		
	Sector Total Plus Recent Actions	**5.4**	**20.2**	**125.5**	**Not quantified**		

GHG = greenhouse gas; $MMtCO_2e$ = million metric tons of carbon dioxide equivalent; $/$tCO_2e$ = dollars per metric ton of carbon dioxide equivalent.

* These totals account for the interaction between RCI policies. The benefits and costs of RCI policies overlap as follows: between residential and commercial new construction in RCI-1, RCI-2, and RCI-10; between RCI–4 and energy efficiency efforts in government and schools within RCI-2 and RCI-10; between RCI-7 and parts of RCI-2,

RCI-4, and RCI-10; and between RCI-11 and parts of RCI-2, RCI-4, and RCI-10. Overlaps also occur between RCI and Energy Supply (ES), to the extent that demand is reduced by RCI measures, and generation emits less GHGs after ES policies; adjustments for overlaps between RCI and ES are quantified in the ES cumulative analysis. An overlap with Agriculture, Forestry, and Waste Management-2 (AFW-2) has been quantified in the AFW cumulative analysis.

† Recent actions include the Energy Independence and Security Act of 2007 Title III (Appliance and Lighting Efficiency), Maryland Energy Efficiency Standards Act of 2007, and EmPOWER MD (HB 374).

Note: The numbering used to denote the above policy options is for reference purpose only; it does not reflect prioritization among these important policy options.

The following policy recommendations reflect consensus positions of the RCI Technical Work Group (TWG) and do not necessarily represent the views of the individual members.

RCI-1. Improved Building and Trade Codes and Beyond-Code Building Design and Construction in the Private Sector

Policy Description

Buildings are significant consumers of energy and other resources, and can contribute to local microclimates. According to the Environmental Protection Agency (EPA), December 2004, in the United States buildings account for 39% of the total energy use, 12% of the water consumption, 68% of the electricity consumption, and 38% of the total carbon dioxide emissions. Given the long lifetime of most buildings, amending state and/or local building codes to include minimum energy efficiency requirements and periodically updating energy efficiency codes could provide long-term GHG savings.

This policy sets a goal for reducing building energy consumption, to be achieved by increasing standards for the minimum performance of new and substantially renovated commercial and residential buildings through the adoption and enforcement of building and trade codes. Building codes would be made more stringent via incorporation of aspects of advanced/next generation building designs and construction standards, such as Leadership in Energy and Environmental Design Green Building Rating System™ (LEED) or a comparable standard. Other aspects of the policy design include:

- Undertaking a comprehensive review of existing State and local building and trades codes in Maryland to determine where increased energy efficiency can be achieved.
- Developing a training and certification program for code officials, builders, and contractors on energy efficiency and related Green building and trade codes, and in code enforcement.
- Providing tools to state and local governments for measurement and tracking of cost savings.
- Incorporating future code upgrades by reference language in the statute or regulation to avoid having to re-open the rule each time the referenced body changes its code.
- Targeting existing buildings for efficiency improvements during both major and minor renovation, through application and enforcement of building codes and/or with tax rebates or other incentives.
- Encouraging or requiring continued high performance of buildings that receive tax rebates or other incentives, through participation in LEED for Existing Buildings (LEED-EB) or comparable standard.
- Allowing compliance flexibility. New and substantially renovated buildings can utilize a combination of increased energy efficiency, switching to low and no carbon-based fuels for previously carbon-based end-uses, off-site purchases on grid supplied “green power” and/or installing on-site off-grid power generating equipment.
- Establishing specific goals for the size of building to be included, e.g., using Montgomery County Bill 17-06 as a model.
- Setting a cap on consumption of energy per unit area of floor space for new buildings.

- Requiring high-efficiency appliances in new construction and retrofits.
- Providing incentives, such as permitting and fee advantages, tax credits, financing incentives (such as "green mortgages"), or other inducements to encourage retrofit of existing residential and commercial buildings or for the development of non-traditional off-grid low and carbon-neutral energy sources. The state can work with financial institutions to develop loan tools for these programs.

Advanced/next-generation building design requirements might include use of specific materials (e.g., local building materials), implementation of specific technologies (e.g., energy-efficient roofing materials and landscaping to lower electricity demand), or attainment of points under an advanced standard (e.g., LEED or a comparable standard). Energy-reduction targets should be periodically reassessed.

Potential measures supporting this policy can include outreach and public education, public recognition programs, improved enforcement of building codes, encouraging or providing incentives for energy tracking and benchmarking, performance contracting/shared savings arrangements, technical support resources for implementation, development of a clearinghouse for information on and access to software tools to calculate the impact of energy efficiency and solar technologies on building energy performance.

Policy Design

Goals:

- Mandating the periodic and regular (no less than every 3 years) review and adoption of State and local building and trades codes, particularly energy efficiency requirements, to ensure best management practices. At least every three years, the state will review (with opportunity for public comment) and adopt the more stringent of the International Code Council (ICC) or American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) standards for energy efficiency.
- Reduce energy consumption per square foot of floor space by 15% by 2010 and 50% by 2020.
- Developing a training and certification program for code officials and contractors on energy efficiency and related Green building and trade codes.

Timing: See above goals. The building and trade related code, permitting and enforcement changes to take place during calendar year 2008.

Parties Involved: The Maryland Department of Housing and Community Development (DHCD) and Municipal and County code officials; Maryland Municipal League (MML) and Maryland Association of Counties (MACo); Maryland Home Builders and Realtors Associations (MHBR); Non-affiliated private builders, engineers and tradesman; Citizen, consumer and community organizations; Electric, water and sewer utilities; Environmental advocacy organizations; Public Service Commission (PSC); Maryland Department of General Services (DGS); Maryland Energy Administration (MEA); Maryland Department of the Environment (MDE); Maryland Department of Labor, Licensing, and Regulation (DLLR); Maryland

Department of Business and Economic Development (DBED); and the Maryland Green Building Council.

Other: Indoor air quality standards, construction waste management and recycling plans and heating, ventilation, and air conditioning (HVAC) and lighting standards, including but not limited to energy efficiency and occupant health and safety, would be developed to complement energy efficiency codes.

Implementation Mechanisms

Education, Training, Certification, and Technical Assistance: Education, training and certification is expected to be a major component of improving building and trade codes. It will be necessary to develop enhanced State mandated training, education and certification for code officials, builders and tradesmen. Education and outreach are important so that consumers and constituents understand the benefits and cost savings for these programs. The training and certification program for code officials and contractors would be based on the State's (MDE) Sediment and Erosion Control "Green Card" training and certification program. It should be designed in concert with a LEED (or comparable standard) certification program but be less intensive and oriented towards a blue collar work force. Funding should be set aside for training and education of building inspectors.

Review of Existing Building and Trades Codes: The state should undertake a comprehensive review of existing State and local building and trades codes in Maryland to determine where increased energy efficiency can be achieved.

Size-Specific Goals: Specific goals by building size can be developed. For example: a new building with a least 10,000 square feet gross floor area (GFA); a renovation or reconstruction of an existing building with at least 10,000 square feet GFA that alters more then 50% of the buildings GFA; and an addition that doubles the buildings footprint and adds at least 10,000 square feet of GFA. See Montgomery County Bill 17-06. (See also State of Washington using the threshold of 5,000 square feet).

Compliance Flexibility: The 2030 carbon-neutral goal, based on Architecture 2030, can be reached for new and substantially renovated buildings by utilizing a combination of increased energy efficiency, switching to low and no carbon-based fuels for previously carbon-based end-uses, off-site purchases on grid supplied "green power" and/or installing on-site off-grid power generating equipment.

Statewide Code and Inspections Program: Understanding the importance of local government adoption and control over code enforcement, there should be a minimum standard established statewide for related codes, permitting and inspection.

Utility Involvement and Assistance: Consider using utility resources to help implement energy codes. This can include energy audits, reviewing and promoting energy codes, interconnection rules, tariffs and connection charges that encourage the construction and rehabilitation of buildings that incorporate energy efficiency.

Permitting and Fee Advantages: Provide programs that speed the permit approval process and reduce the permit and impact fees related to construction to provide incentives to consumers and builders. This could include reduced building permit fees, reduced water and sewer fees and reduced impact fees.

Rewards Programs: Develop systems and programs that reward "beyond code" energy efficiency and emissions reduction improvements, including "green mortgages," and additional floor area ratio and/or zoning density for construction that meets or exceeds energy efficiency programs. Work with financial institutions to develop loan tools for these programs, including non-traditional off-grid low and carbon-neutral energy sources.

Property Tax Incentives: Property tax adjustments that waive or decrease a portion or all of the taxes associated with new construction that meets or exceeds energy efficiency programs. Tax credits for the residential sector could be effective for 2 years and based on the assessed property value of new, private residential units that achieve the beyond code level desired in a given year. Tax credits for the commercial sector could be capped at 10 years and based on the incremental construction cost for new, private commercial buildings that achieve the beyond code level desired in a given year.

High Performance Building Codes for Energy and Efficiency: These specify minimum energy efficiency requirements for new buildings or for existing buildings undergoing a major renovation and/or additions. The minimums specified could be updated.

Tax Rebates or Other Incentives for Ongoing Building Performance: Encourage or require participation in LEED for Existing Buildings (LEED-EB) or a comparable standard to ensure continued high building performance through proper building operations and maintenance.

Increased Tax Incentives: Develop incentives for building energy efficiency improvements

Empower Maryland Program: This policy could build upon this existing program (applicable to state buildings) by encouraging private sector facilities to meet the same building design and performance standards.

Strengthen Regional Partnerships: Such as Northeast Energy Efficiency Partnership (NEEP), in order to assure consistency and economies of scale.

Related Policies/Programs in Place

Building Codes: Maryland has adopted the 2006 edition of the International Building Code (IBC) and International Energy Conservation Code (IECC). Many local governments, including the City of Annapolis, have adopted the 2006 edition of the International Energy Efficiency Code.

Beyond Code: U.S. Green Buildings Council's LEED™ New Construction (LEED-NC), LEED-EB, LEED Core and Shell (LEED-CS), and LEED Homes (LEED-H)**,** EPA ENERGY STAR and High Performance Home 100 (HPH100), Architecture 2030, and the American National Standard Institute's National Green Building Standard (under development).

Legislative Action: Local governments (see Montgomery County Bill 17-06 and Green Schools Focus, the City of Baltimore and the City of Annapolis adopted) have proposed and adopted standards for building energy and efficiency; interest in "standard 189" code, the MEA's incentives for installation of certain renewable energy technologies; the PSC's rules allowing net-metering from qualifying self-generators of renewable energy, including photovoltaics (PV), wind, and biomass, up to 200 kilowatts; the PSC's Renewable Portfolio Standard, which requires that a minimum percentage of retail energy sales be derived from renewable sources; Executive Order 01.01.2001.02 Sustaining Maryland's Future with Clean Power, Green Buildings and Energy Efficiency; the Maryland Strategic Energy Investment Program (SB 268); Maryland Energy Efficiency Standards Act of 2007; and EmPOWER MD (HB 374).

Federal Legislation: Energy Independence and Security Act of 2007 Title III (Appliance and Lighting Efficiency) and Title IV (Energy Savings in Building and Industry).

Type(s) of GHG Reductions

Reduction in GHG emissions (largely CO_2) from avoided electricity production or on-site fuel combustion.

Estimated GHG Reductions and Net Costs or Cost Savings

Table F-1 presents the estimated GHG reductions and net costs or costs savings from implementing RCI-1.

Table F-1. Estimated GHG reductions and net costs of or cost savings from RCI-1

	GHG Reductions ($MMtCO_2e$)			Gross Costs (Million $)	Gross Benefits (Million $)	Net Present Value 2008–2020 (Million $)	Cost-Effective-ness ($/tCO_2e$)
	2012	2020	Total 2008–2020				
RCI–1 Total	**0.6**	**2.4**	**13.8**	**$537**	**–$1,063**	**–$527**	**–$38**
Residential New/Major Renovations	0.5	2.0	11.9	$476	–$913	–$437	–$37
Commercial New/Major Renovations	0.1	0.4	2.0	$61	–$150	–$89	–$45

GHG = greenhouse gas; $MMtCO_2e$ = million metric tons of carbon dioxide equivalent; $/$tCO_2e$ = dollars per metric ton of carbon dioxide equivalent.

Data Sources:

- Building Codes Assistance Project (BCAP), personal communications with Aleisha Khan
- R. Ewing, K. Bartholomew, S. Winkelman, J. Walters, and D. Chen. 2007, "Growing Cooler: The Evidence on Urban Development and Climate Change" Urban Land Institute. http://www.smartgrowthamerica.org/gcindex.html.

Benefits:

- BCAP Code Status Detail. Found at: http://www.bcap-energy.org/code_status.php?STATE_AB=MD.
- Maryland Additional State Info. Found at: http://www.energycodes.gov/implement/state_codes/state_stat_more.php?state_AB=MD

- R. G. Lucas of Pacific Northwest National Laboratory. "Analysis of Energy Saving Impacts of New Residential Energy Codes for the Gulf Coast," Table 3. Annual Energy Costs (Space Heating and Cooling Only) of Whole Building Alternatives—House with Slab-on-Grade Foundation, p. 5, January 2007. http://www.energycodes.gov/pdf/pnnl16265.pdf (accessed January 2, 2008)
- M. A. Halverson, K. Gowri, and E. E. Richman of Pacific Northwest National Laboratory. "Analysis of Energy Saving Impacts of New Commercial Energy Codes for the Gulf Coast," Appendix B. Table B-1. Office Results for New Orleans, p. 33, December 2006. http://www.energycodes.gov/pdf/pnnl16282.pdf (accessed January 6, 2008)
- Gregory H. Kats, "Green Building Costs and Financial Benefits," 2003, Figure 2, p. 4, http://www.cap-e.com/ewebeditpro/items/O59F3481.pdf (accessed January 7, 2008).

Costs:

- Greg Katz and Jon Braman. Greening Buildings and Communities: Costs and Benefits. Draft Findings on the Cost Premium, Energy and Water Savings by LEED Level. 2008. (unpublished, under review)
- ICC Code Website. Building Valuation Data. http://www.iccsafe.org/cs/techservices/ (accessed March 13, 2008).

Quantification Methods:

Benefits:

The timing of the implementation of future building codes was determined. Then, the percentage of new and renovated homes and buildings that would comply with the new building codes instead of 2006 IECC was determined. Incremental energy savings goals were also determined based on the current energy savings trajectory for residential and commercial buildings for future building codes. After the energy savings was broken out by fuel type, the greenhouse gas emission reductions were calculated using emissions factors for each fuel type. The avoided costs by fuel type were also calculated.

Costs:

Incremental construction cost percentages were multiplied by the average cost of Maryland homes and office buildings to determine the incremental cost per building for different levels of energy savings associated with different programs.

Key Assumptions:

While this policy applies to new structures, existing structures undergoing major renovations and existing structures undergoing more minor renovations, the impacts from existing structures undergoing more minor renovations were not modeled because the number of structures involved is not known. Also, there would be a wide variety of measures implemented with a range of possible energy savings.

The analysis of costs and GHG benefits are limited to energy efficiency measures. Alternative means of reaching the goals (switching to low and no carbon-based fuels for previously carbon-based end-uses, off-site purchases on grid supplied "green power" and/or installing on-site off-grid power generating equipment) are not modeled.

Analysis of GHG benefits and costs for implementing goals by size of building are not modeled.

Assuming that a portion of the new homes and buildings do not comply with the building code upgrades, a portion of the new homes and buildings will not be upgrading to future building codes or going beyond code.

The building code 3-year cycle will start in 2009. Incorporation of beyond-code elements into building codes will occur starting with the second code cycle in 2012.

This analysis also assumes that improvements are incremental to a scenario where the status quo persists. The benefits and costs for new homes are derived from the fact that these homes are built to building codes in the future that are more stringent than the current code. The benefits and costs for renovated homes are derived in the same way; instead of being renovated to current code, these homes will be renovated to more stringent codes in the future.

A new building is defined as any building that is built between 2009 and 2020. A renovated building is defined as any building that undergoes major renovations between 2009 and 2020.

For ease of analysis, Center for Climate Strategies (CCS) and the RCI TWG (collectively, "we") are assuming that the energy reductions from implementing 2006 IECC are similar to the energy reductions from implementing IBC 2006. This is supported by an email from Mark Halverson of the Pacific Northwest National Laboratory stating, "The IBC is a building code and not an energy code. The IBC references the IECC for energy issues and so unless a state or local jurisdiction makes modification to the IBC (which many do), they will end up with the corresponding version of the IECC."

Additionally, we are assuming that building codes are implemented in the same year that they are released and adopted. Mark Halverson of the Pacific Northwest National Laboratory noted that building codes are currently being adopted by particularly aggressive states in the year they are released or even before they are released. Vermont is a good example of a state where this is occurring. If builders are kept in the loop on potential updates during the course of the multi-year planning stage and the updates are not so stringent that there are barriers to implementation, quick implementation is possible.

Benefits: Table F-2 presents the key assumptions for the potential benefits from this policy.

Table F-2. Key assumptions for benefits from RCI-1

Assumption	Residential Sector	Commercial Sector	Notes
Number of new homes/buildings	289,940	6,784	Scaled from regional data using population
Ratio of new vs. renovated homes/buildings	1.00	1.00	Placeholder assumption
Building code compliance rate	70%	70%	Placeholder assumption
Number of new and renovated homes/buildings participating in building code updates	405,916	9,498	Calculated assumption
Average energy use for a	44,734 Btu/sq.	65,302 Btu/sq.	Calculation of energy use divided by projected number of square

Assumption	Residential Sector	Commercial Sector	Notes
new/renovated home/building	ft./year	ft./year	feet
Average square footage per new/renovated building	1,700	11,829	Calculation of projected square footage of buildings divided by the projected number of buildings
Current stock vs. new stock energy savings	20%	16%	Calculated using Gulf Coast studies on building codes
Energy savings for new and renovated homes/buildings from future building codes (as compared with 2006 IECC)	2009 IECC: 30% 2012 IECC: 35% 2015 IECC: 40% 2018 IECC: 45%	2009 IECC: 5% 2012 IECC: 30% 2015 IECC: 33% 2018 IECC: 36%	Provided by Aleisha Khan at BCAP
Energy savings goals	2009: 30% 2012: 40% 2015: 45% 2018: 50%	2009: 15% 2012: 30% 2015: 40% 2018: 50%	Assumes more aggressive building codes incorporating elements of LEED or other beyond code measures
Proportion of energy savings by fuel type	53% Electricity 47% Natural gas	51% Electricity 49% Natural gas	Based on the breakout in the Inventory & Forecast
Emissions factors	Electricity average (2008–2020): 0.77 tCO_2e/MWh, or 224.3 (tCO_2/BBtu), Natural Gas: 54 tCO_2e/BBtu		Electricity: generation-weighted average of projected annual CO_2e emissions by utilities and non-utilities (excluding commercial and industrial combined heat and power [CHP]) for the marginal fuels. Generation and emissions projections are taken from the Maryland GHG emissions forecast. Coal, natural gas, and petroleum are assumed to be on the margin. Natural Gas: EPA 2003 US GHG inventory, Appendix A
Transmission and distribution (T&D) electricity loss	10%		Placeholder assumption
Avoided energy costs	Electricity: $24,434/BBtu (2006$) Natural Gas: $8,061/BBtu (2006$)		Maryland-specific; calculated based on 15-year Baltimore Gas & Electric (BGE) and 5-year Potomac Electric Power Company (Pepco) price schedules for qualifying facilities purchased power, weighed for on-peak and off-peak usage, and for the fraction of Maryland's electricity supplied by each of the three utilities.

BBtu = billion British thermal units; sq. ft. = square feet; IECC = International Energy Conservation Codes; BCAP = Building Code Assistance Project; LEED = Leadership in Energy and Environmental Design Green Building Rating System™; tCO_2e = metric tons of carbon dioxide equivalent; MWh = megawatt-hours; GHG = greenhouse gas.

Costs: Table F-3 presents the key assumptions for the potential costs of this policy.

Table F-3. Key assumptions for costs of RCI-1

Assumption	Residential Sector	Commercial Sector	Notes
Real Discount Rate	5%		Placeholder assumption

Capital Recovery Factor for Levelization	6.20% Interest rate: 5.0% Period: 30 years	6.52% Interest rate: 5.5% Period: 30 years	Calculated assumption
Average Construction Cost of a Home/Building	$187,425	$1,546,610	Based on national estimates from the ICC
Incremental Costs from Building Code Improvements	2009: 2% 2012: 2% 2015: 3% 2018: 4%	2009: 0.5% 2012: 2% 2015: 2% 2018: 4%	Based on the incremental costs of LEED levels with like energy savings

ICC = International Code Council; LEED = Leadership in Energy and Environmental Design Green Building Rating System™.

For simplicity, every home or building, without regard for the year when it is retrofitted or built, is assumed to achieve the energy savings goals as written. Please note that there are alternate ways to analyze this policy, including assuming that a proportion of the homes and buildings that participate in a given year attain energy savings that are less than the goal and the remaining proportion exceed the goal.

It is assumed that renewable energy purchases (off-site electricity generation from renewables) are one of the ways with which the home or building can accomplish the given goal.

Key Uncertainties

Assumptions for which there was little to no supporting data include:

- The number of renovated homes and buildings;
- The building code compliance rate; and
- The cost of building code implementation.

Additionally, the cost of new construction is based on national estimates. Region-specific estimates are not available but may be either higher or lower than these costs.

In its "Growing Cooler" report, the Urban Land Institute (ULI) predicts a reversal of 20th-century sprawling development patterns towards increasing demand for compact development, due in part to a relative decline in the share of households with children versus those made up of older Americans (http://www.smartgrowthamerica.org/gcindex.html). Energy consumption in large-lot homes is generally higher than in compact development, which tends to be more tightly built, and for which much of the heat loss occurs into adjacent unit(s). If Maryland experiences higher demand for compact development, as projected by ULI on a nation-wide basis, baseline energy consumption could be lower, and hence costs of attaining a given level of energy savings under RCI-1 would be lower. No adjustment has been made to the policy analysis or baseline, because estimates of the energy savings associated with compact development vary widely, and data to apply these efficiencies to the baseline in Maryland are lacking.

Estimates for the incremental cost of beyond-code improvements vary widely, and these assumptions represent the lowest costs seen to date.

Also, there is a need to better define and distinguish major from minor renovations.

There is a need to define the threshold that would trigger the need for a building code permit.

Additional Benefits and Costs

- Resource conservation, including water – lower water demand leads to lower costs and reduced energy use for water production. In the City of Annapolis, water utility and sewer pumps account for around 23% of energy use and 30% of carbon dioxide equivalent (CO_2e) emissions.
- Indoor comfort and air quality improvements, with related improvements in health and productivity.
- Savings to consumers and business on energy bills. Benefits to the low income by reducing utility costs.
- Electricity system benefits: reduced peak demand, reduced capital and operating costs, improved utilization and performance of electricity system.
- Reduced pollutants from emissions, improved health from fewer pollutants and particulates and reduced water use for cooling.
- Green-collar employment expansion and economic development.
- Reduced dependence on imported fuel sources.
- Reduced energy price increases and volatility.

Feasibility Issues

A 3-year cycle for updates could be challenging to implement given that smaller counties may not have the administrative staff to keep up with frequent code changes. A greater number of cycles with less substantial updates may result in a loss of attentiveness by smaller counties. Fewer updates that are each more impactful may be more feasible for smaller counties in particular.

The energy savings trajectory is more aggressive for the Commercial sector as compared with the Residential sector. Because Commercial building codes are not slated to achieve the same reductions as the Residential building codes, a greater effort must be made with regard to increasing the stringency of these building codes such that the Commercial sector meets the same goal as the Residential sector. However, the feasibility of the energy savings trajectory as defined for the Commercial sector is unknown.

Status of Group Approval

Approved.

Level of Group Support

Unanimous.

Barriers to Consensus

Not applicable.

RCI-2. Demand-Side Management/Energy Efficiency Programs, Funds, or Goals for Electricity and Natural Gas (Including Expansion of Existing Programs and Peak Load Reduction)

Policy Description

This option focuses on increasing investment in electricity and natural gas demand-side management (DSM) programs through programs run by the MEA, energy service companies (ESCOs), utilities, or others, in order to meet the goals of overall reduction in energy consumption as well as a reduction in peak load demands. Decreasing consumption will have immediate impacts on greenhouse gas emissions. DSM activities may be designed to work in tandem with other recommended strategies that can also encourage efficiency gains.

This policy involves the creation of a Public Benefit Fund (PBF) with the goal of increasing the funding and scope of existing energy efficiency programs. Implementation of energy efficiency programs could also include the following elements:

- Establishment of ongoing, high-level statewide resource planning in coordination with the PSC.
- Aggressive marketing of and advertisement for energy efficiency programs.
- Scaling-up of training and education in energy efficiency measures.
- Use of tax policy to facilitate implementation of energy efficiency measures.
- Facilitation of the whole process of implementing energy efficiency measures by: overcoming information hurdles; subsidizing energy auditing and implementation costs; setting up recycling/scrapping programs of old appliances; reduction of overall transaction costs.

RCI-2 is intended to achieve the incremental difference between the energy efficiency gains from RCI-10 (Energy Efficiency Resource Standard [EERS]) and statewide application of the EmPOWER Maryland goals (15% per capita electricity and natural gas use by 2015).

Policy Design

Goals:

- Together with RCI-10, achieve a 15% reduction in per capita electricity and natural gas use by 2015. The budget for this policy shall be up to $100 million per year.
- 100% capture of achievable cost-effective energy efficiency by 2025.
- Individual targets for different sectors to be defined in wedges, by how much each sector can potentially contribute to the overall goal.

Timing: Early action to begin with increased funding in current state programs in 2008.

Parties Involved: MEA, PSC, utility companies, generators and distributors, advocacy groups, Energy Service Companies, and local governments.

Other: Supporting measures include providing training for contractors, builders, and other specialists in expectation of increased demand (see RCI-5) and encouraging local governments to adopt energy efficiency targets (see RCI-4).

Implementation Mechanisms

- Establish ongoing, high-level statewide resource planning in coordination with the PSC.
- Facilitate the whole process of implementing energy efficiency measures by overcoming information hurdles, setting up recycling/scrapping programs for old appliances, and reducing overall transaction costs. Invest in consumer education and program marketing.
- Develop an administrative framework for coordination and oversight of energy efficiency programs. MEA could be the administrative entity for the implementation of the PBF. The administrative body would develop a transparent contracting and procurement process for the selection of a variety of implementation contractors including energy service companies, nonprofit agencies, utilities, and other third parties.
- Scale up current successful energy efficiency programs to increase coverage where appropriate rather than create redundant additional programs.
- Expand energy audit programs for all sectors and offer incentives and assistance for building and production facilities owners to follow up on audit recommendations. These incentives can be tax deductions for conducted audits, days off from work for employees attending their home energy audit, and other mechanisms that reduce transaction costs.
- Provide incentives to address potential "lost opportunities" in new construction, equipment and appliance replacement, and retrofits.
- Promote the purchase of appliances, thermostats, and compact fluorescent lamps (CFLs) that qualify for current ENERGY STAR or better. (See also RCI-7 and RCI-11.)
- Implement energy labeling for new homes and encourage or mandate it for existing homes for further sales or leases.
- Review efficiency best practices for specific industries and conduct training on these practices.
- Promote specific technologies, including incentives for solar hot water installation. Solar hot water systems reduce use of other fuels for water heating (largely electricity and natural gas), thereby avoiding GHG emissions, reducing Maryland's dependence on natural gas, and potentially reducing the price of this fuel.

Possible funding sources would be proceeds of Regional Greenhouse Gas Initiative (RGGI) allowance auctions, Environmental Trust Fund, or a new public benefits charge.

Related Policies/Programs in Place

The EmPOWER Maryland goal, set by Governor O'Malley in July 2007, established a statewide goal of reducing per capita electricity consumption and peak demand by 15% by 2015. Modeled on the governor's goal, SB 205/HB 374 requires electric utilities to submit plans to reduce per capita electricity consumption by 10% by 2015.

The Maryland Energy Efficiency Standards Act of 2007 requires the MEA to adopt regulations establishing minimum efficiency standards for a number of consumer products.

RGGI auction proceeds may be dedicated to Energy efficiency. HB 0368/SB 268 established the Maryland Strategic Energy Investment Program and Fund, to decrease energy demand and increase clean energy supply utilizing proceeds from the sale of RGGI allowances. This legislation has not been reflected in the analysis that follows.

ESCOs in Maryland offer Energy Performance Contracting (EPC) to government agencies and the commercial sector. Performance contracting is a self-financing mechanism for improvements for energy efficiency. In the commercial sector, the money that businesses save through less energy consumption is leveraged to pay to the ESCO for financing, installing, operating, and maintaining the energy efficiency measures. After a predetermined period of time of paying the ESCO via the energy bill, all of the energy savings revert to the business owner. $395 million have been loaned since 1995. Maryland state agencies finance EPCs through a private sector financial institution and energy savings from the installed projects are paid from state agency operating budgets to the financial institution. ESCOs that implement state energy projects guarantee the energy savings to the state agency.

On the industry side, MEA has provided limited free energy assessments for Maryland industries through the Industrial Energy Assessment, in partnership with the University of Maryland and the United States Department of Energy (DOE).

The MEA has several programs in place to help finance energy efficiency improvements (see RCI-3).

The Energy Independence and Security Act of 2007 has three titles particularly relevant to RCI-2: Title III (Appliance and Lighting Efficiency), Title IV (Energy Savings in Building and Industry), and Title V (Energy Savings in Government and Public Institutions).

Type(s) of GHG Reductions

Reduction in GHG emissions (largely CO_2) from avoided electricity production or on-site fuel combustion.

Estimated GHG Reductions and Net Costs or Cost Savings

Table F-4 presents the estimated GHG reductions and net costs or costs savings from implementing RCI-2.

Table F-4. Estimated GHG reductions and net costs of or cost savings from RCI-2

	GHG Reductions ($MMtCO_2e$)			Gross Costs (Million $)	Gross Benefits (Million $)	Net Present Value 2008–2020 (Million $)	Cost-Effective-ness ($\$/tCO_2e$)
	2012	2020	Total 2008–2020				
RCI–2 Total	1.8	4.5	35.0	$903	–$2,801	–$1,898	–$54
Electric demand-side management	1.5	3.7	28.7	$696	–$2,151	–$1,454	–$51
Natural gas demand-side management	0.3	0.8	6.3	$206	–$650	–$443	–$70

GHG = greenhouse gas; $MMtCO_2e$ = million metric tons of carbon dioxide equivalent; $\$/tCO_2e$ = dollars per metric ton of carbon dioxide equivalent.

Data Sources:

Energy efficiency potential:

- Maryland Public Interest Research Group (MaryPIRG) Foundation 2005. Power Plants and Global Warming: Impacts on Maryland and Strategies for Reducing Emissions.
- American Council for an Energy-Efficient Economy (ACEEE) 2004. The Technical, Economic and Achievable Potential for Energy-Efficiency in the U.S. – A Meta-Analysis of Recent Studies, available at www.aceee.org/conf/04ss/rnemeta.pdf.
- Synapse Energy Economics 2004. A Responsible Electricity Future: An Efficient, Cleaner and Balanced Scenario for the U.S. Electricity System.
- ACEEE 2005. Examining the Potential for Energy Efficiency to Help Address the Natural Gas Crisis in the Midwest.
- Optimal Energy, Inc., et al. 2006. Natural Gas Energy Efficiency Resource Development Potential in New York.
- GDS Associates, Inc. 2006. The Maximum Achievable Cost Effective Potential for Gas DSM in Utah for the Questar Gas Company Service Area.

Cost of energy efficiency measures in Maryland

- Potomac Electric Power Company (Pepco) and Baltimore Gas & Electric (BGE) filings.

Experience in other states on cost of energy efficiency:

- Bill Prindle 2007. "Energy Efficiency: The First Fuel in the Race for Clean and Secure Energy," Presentation at the National Action Plan for Energy Efficiency (NAPEE) Southeast Energy Efficiency Workshop on September 28, 2007, available at http://www.epa.gov/solar/pdf/southeast_28sep07/prindle_new_napee_presentation_atlanta_9_28_07.pdf.
- ACEEE 2004. Five Years In: An Examination of the First Half-Decade of Public Benefits Energy Efficiency Policies, April 2004.
- Gene Fry, "Massachusetts Electric Utility Energy Efficiency Database", Massachusetts Department of Telecommunications and Energy, 2003 edition.

- Heschong Mahone Group, Inc. 2005. New York Energy $martSM Program Cost-Effectiveness Assessment, prepared for NYSERDA, June 2005.
- Western Governor's Association (WGA) 2006. The Energy Efficiency Task Force Report to the Clean and Diversified Energy Advisory Committee of the Western Governors Association, January 2006.
- GDS Associates, Inc. 2007. Electric Energy Efficiency Potential Study for Central Electric Power Cooperative, Inc. Final Report. Updated September 21, 2007.

Cost of saved natural gas:

- Optimal Energy Inc. et al. 2006. Natural gas Energy Efficiency Development Potential in New York, October 31, 2006.
- Southwest Energy Efficiency Project 2006. Natural Gas Demand-Side Management Programs: A National Survey, available at www.swenergy.org.

Quantification Methods:

- Develop energy savings targets for RCI-2 and RCI-10.
- Develop a maximum achievable DSM savings scenario, which aims to attain the 15% energy savings goal by 2015. After 2016, the maximum achievable annual savings scenario for gas and electric DSM draws on experience in other states.
- Estimate energy savings from RCI-2 as the difference between RCI-10 and the maximum achievable DSM savings scenario.
- Estimate energy reduction based on the percentage reduction goal in per capita electricity and natural gas each year until 2015 for RCI-2 and RCI-10. (The target for RCI-2 is set to the incremental energy savings required to achieve 15% by 2015 reduction goal, over and above RCI-10's contribution to the overall goal.)
- Estimate the total cost of electricity and natural gas savings, capped at $100 million per year.
- Estimate the GHG emissions reduction through the electric energy efficiency measures.

Key Assumptions:

- *Discount rate:* Same assumptions as used for RCI-1.
- *Cost of financing:* 0% interest rate (DSM costs are incurred as the Systems Benefits Charge (SBC) is collected).
- *Avoided cost of electricity and fuels:* Same assumptions as used for RCI-1.
- *Maximum achievable electricity and natural gas efficiency savings, 2008 to 2015*: Table F-5 presents the assumed maximum achievable electricity and natural gas efficiency savings through 2015 for RCI-2 and RCI-10 combined.

Table F-5. Maximum achievable electricity and natural gas efficiency savings for RCI-2 and RCI-10, 2008-2015

Year	Target
2008	1%
2009	2%
2010	3.5%
2011	5%
2012	7%
2013	9%
2014	12%
2015	15%

- *Maximum achievable electricity and natural gas efficiency savings after 2015:* 1.6% per year for electricity efficiency and 1.2% per year for natural gas efficiency based on a number of DSM potential studies and experiences by leading electric and natural gas utilities.
- *Achievable electric efficiency potential:* "The state has sufficient efficiency potential to reduce power demand by 14 million megawatt-hours (MWh), or 16.5% of total electricity demand projected for 2018. This would return electricity demand in 2018 to 2006 levels." (Source: MaryPIRG Foundation 2005).
- *Achievable natural gas potential:* ACEEE 2004.
- *Cost of electric efficiency measures*: 3 cents per kilowatt-hour (kWh) of saved electricity based on experience in other states:

Table F-6. Experience in other states on the cost of saved energy (CSE)

State/Utility	CSE ($kWh)	Program Year	Source
Western utilities	0.025	1978–2004	WGA, 2006
Northwest Energy	0.02	2006	Montana PSC Docket No.: D2005.5.88, July 12, 2006
New York	0.03	2004	Heschong Mahone Group, Inc., 2005
MA IOUs	0.038	2002	Gene Fry, 2003
California	0.03	N/A	ACEEE, 2004
Connecticut	0.023	N/A	ACEEE, 2004
New Jersey	0.03	N/A	ACEEE, 2004
Vermont	0.03	N/A	ACEEE, 2004
North Carolina	0.029	2006-2017	GDS Associates, Inc., 2006

CSE = cost of saved energy; kWh = kilowatt hours; WGA = Western Governors' Association; PSC = Public Service Commission; N/A = not applicable; ACEEE = American Council for an Energy-Efficient Economy.

- *Cost of saved natural gas:* $2.47/million British thermal units (MMBtu) based on Optimal Energy Inc. et al. (2006), which investigated the natural gas energy efficiency potential in downstate (urban and suburban) and upstate (predominantly rural) New York State. The downstate cost of saved natural gas is used here, as it is assumed to be more applicable to State of Maryland.

- *Utility cost of saved energy:* the utility cost of saved energy (including incentives, marketing and admin) is assumed to be 60% of the total cost of energy efficiency. This cost does not include costs paid by participants.
- *Electric efficiency measure lifetime:* 13 years on average for electricity DSM.
- *Displaced emissions*: Same assumptions as used for RCI-1.

Key Uncertainties

The source of funding to implement the aggressive DSM program envisioned here is uncertain.

Additional Benefits and Costs

- Indoor comfort and air quality improvements, with related improvements in health and productivity.
- Savings to consumers and business on energy bills. Benefits to the low income by reducing utility costs.
- Electricity system benefits: reduced peak demand, reduced capital and operating costs, improved utilization and performance of electricity system.
- Reduced risk of power shortages.
- Reduced pollutants from emissions, improved health from fewer pollutants and particulates and reduced water use for cooling.
- Green-collar employment expansion and economic development.
- Reduced dependence on imported fuel sources.
- Reduced energy price increases and volatility.

Feasibility Issues

None noted.

Status of Group Approval

Approved.

Level of Group Support

Unanimous.

Barriers to Consensus

Not applicable

RCI-3. Low-Cost Loans for Energy Efficiency

Policy Description

Revolving loan funds are effective tools for promoting energy efficiency investment. This policy involves the creation of revolving low-interest loan fund(s) targeting distribution service areas that are not covered by existing utility programs, as well as expanding the scope of existing programs in areas that are currently covered. RCI-3 is intended to complement the programs being considered as part of RCI-2 and RCI-10.

The policy could help a variety of customer classes improve the energy efficiency of their building or residence through one or more specific measures. While this policy does not support comprehensive improvements for each participant, the measures that are installed would likely be some of the most needed improvements and thus deliver significant energy savings. Measures that are good candidates for this program would likely include appliance replacements and/or furnace, boiler, and/or hot water heater upgrades. This policy is not intended to fund major structural changes to residences and buildings or large-scale renovations such as replacing roofs or windows. The action would initially be targeted at residential customers, small businesses and low-income consumers, who often rent rather than own their property, and then expanded to other customer classes, including larger businesses and the industrial sector.

These programs could be designed so as to offer low-income residents and other underserved customer classes energy efficiency services with a minimum of up-front costs, and could be marketed through an aggressive campaign of targeted outreach to these sectors. Terms of the loan can be designed to allow loan repayment as cost savings on utility bills are realized. Programs can be designed to work with both landlords and tenants, including small businesses. The policy design could also complement measures or ordinances that require existing buildings to be brought up to the current code at the point of sale, and with new buildings, especially those built "on spec" and/or that are "flipped" to another party at the time of their sale.

Policy Design

Goals: Establish revolving loan funds for small-scale residential and commercial energy efficiency projects. For analysis purposes, government funding will provide $15 million ($10 million for the Residential sector and $5 million for the Commercial sector), to be leveraged with private capital ($40 million for the Residential sector and $20 million for the Commercial sector) to create a larger fund and allow for greater participation. It may be appropriate for actual fund levels to be higher than stated here.

Timing: Applications for loan funds will be reviewed in 2008 and allocation and use will occur starting in 2009.

Parties Involved: Residential and commercial property owners and tenants, government housing and other state and federal government agencies, weatherization and energy service providers, local business associations, community action agencies/human resource development councils, and non-governmental organizations such as Habitat for Humanity.

Other: New programs should build on the state's previous experience with weatherization programs. A review of past programs should be conducted.

Implementation Mechanisms

Implement loan programs to target difficult-to-reach populations. Pay-as-you-save programs, or other loan programs that link energy efficiency savings to the meter to pay for them over time, should be included in the suite of loan programs. Utilities would be encouraged to submit proposals to the PSC, which would review and have authority to approve proposals.

The program could also be first targeted to eligible homes, including those whose household income is below 150% of the federal poverty level, and to businesses with fewer than 25 employees. Other customer sectors can be reviewed for eligibility for program in the future.

Complementary measures to target rental properties may be needed. The state should consider the feasibility of the following measures:

- Completing a retro-commissioning program on rental properties whose occupants have or are expected to have long tenancies, such as housing for the elderly, low-income projects and small businesses, to bring these units up to the latest building and appliance codes by 2014.
- Establishing and enforcing requirements that rental properties meet energy and appliance codes.
- Requiring landlords to meet efficiency standards (such as current ENERGY STAR or better) at the time the rental occupancy changes.
- Providing income tax credits for rental property owners who weatherize rental properties to meet energy efficiency standards set by the program.
- Disclosing utility bills for a dwelling at the time of sale or rentalf.
- Enact tenants' rights laws relating to energy efficiency, possibly including tenants' rights to request an energy audit of their rental.
- Benchmarking rental properties using the ENERGY STAR benchmarking program or equivalent. Target low performing buildings, using a combination of incentive payments from RCI-2 and financing to produce the highest possible improvements.

Related Policies/Programs in Place

The State Agency Loan Program (SALP) is a revolving loan program that provides approximately $1 million in no-interest loans to state agencies for energy efficient improvements.

The Community Energy Loan Program (CELP) funds the identification and implementation of energy efficiency improvements for local governments, schools and non-profit organizations. CELP permits borrowers to pay the loans with the cost savings generated by the improvements. CELP funds $1.5 million in new projects every year.

Home buyers in southern Maryland are eligible for an ENERGY STAR mortgage plan offered by the Southern Maryland Energy Cooperative if they purchase an ENERGY STAR home.

Although the additional features of an ENERGY STAR residence increase the sale price of the home, participating mortgage providers offer a reduction of loan origination fees, discounted interest rates, and may include cash back at closing. While this program focuses on home owners, it could be reviewed for its relevance, and considered for adoption/expansion for rental properties. Some of the model programs and policies in other jurisdictions are

- The New Hampshire "pay as you save" program and other bill financing mechanisms.
- California's Energy Efficiency Based Utility Allowance Schedule attempts to correct the split incentive problem on rental properties. Eligible projects must be 15% better than code for new projects, and 20% improvement, compared to previous baseline, for existing projects.
- Energy Savings Insurance (used in Canada, concept developed by Evan Mills, Lawrence Berkeley Labs). Property owners whose buildings are some percentage (10%–20%) better than code earn a rebate on their insurance. In another flavor, more focused on larger buildings, an insurance policy is written to underwrite the performance of EE and guarantee its persistence over time.

The Maryland Strategic Energy Investment Program (SB 268) will target electricity consumption in the low- to moderate-income residential sector.

The EmPOWER Maryland goal, set by Governor O'Malley in July 2007, established a statewide goal of reducing per capita electricity consumption and peak demand by 15% by 2015. Modeled on the governor's goal, SB 205/HB 374 requires electric utilities to submit plans to reduce per capita electricity consumption by 10% by 2015.

The Maryland Energy Efficiency Standards Act of 2007 requires the MEA to adopt regulations establishing minimum efficiency standards for a number of consumer products.

Recent federal legislation that may facilitate efforts under RCI-3 includes the Energy Independence and Security Act of 2007, particularly Title III (Appliance and Lighting Efficiency) and Title IV (Energy Savings in Building and Industry).

Type(s) of GHG Reductions

Reduction in GHG emissions (largely CO_2) from avoided electricity production or on-site fuel combustion.

Estimated GHG Reductions and Net Costs or Cost Savings

Table F-7 presents the estimated GHG reductions and net costs or costs savings from implementing RCI-3.

Table F-7. Estimated GHG reductions and net costs of or cost savings from RCI-3

	GHG Reductions ($MMtCO_2e$)			Gross Costs (Million $)	Gross Benefits (Million $)	Net Present Value 2008–2020 (Million $)	Cost-Effective-ness ($\$/tCO_2e$)
	2012	2020	Total 2008–2020				
RCI–3 Total	**0.3**	**0.5**	**4.1**	**$163**	**–$351**	**–$87**	**–$45**
Residential	0.2	0.4	3.2	$137	–$72	–$35	–$42
Commercial	0.1	0.1	0.9	$26	–$79	–$53	–$59

GHG = greenhouse gas; $MMtCO_2e$ = million metric tons of carbon dioxide equivalent; $\$/tCO_2e$ = dollars per metric ton of carbon dioxide equivalent.

Data Sources:

- *Cost of energy efficiency measures in Maryland:* Pepco and BGE filings.
- Experience in other states on cost of energy efficiency:
  - Bill Prindle 2007. "Energy Efficiency: The First Fuel in the Race for Clean and Secure Energy," Presentation at the NAPEE Southeast Energy Efficiency Workshop on September 28, 2007, available at http://www.epa.gov/solar/pdf/southeast_28sep07/prindle_new_napee_presentation_atlanta_9_28_07.pdf.
  - ACEEE 2004. Five Years In: An Examination of the First Half-Decade of Public Benefits Energy Efficiency Policies, April 2004.
  - Gene Fry, "Massachusetts Electric Utility Energy Efficiency Database", Massachusetts Department of Telecommunications and Energy, 2003 edition.
  - Heschong Mahone Group, Inc. 2005. New York Energy $martSM Program Cost-Effectiveness Assessment, prepared for NYSERDA, June 2005.
  - Western Governor's Association (WGA) 2006. The Energy Efficiency Task Force Report to the Clean and Diversified Energy Advisory Committee of the Western Governors Association, January, 2006.
  - GDS Associates, Inc. 2007. Electric Energy Efficiency Potential Study for Central Electric Power Cooperative, Inc. Final Report. Updated September 21, 2007.
- *Cost of saved natural gas:* Optimal Energy Inc. et al. 2006. Natural Gas Energy Efficiency Development Potential in New York, October 31, 2006.

Quantification Methods:

Benefits:

Assumptions about the funding pool, the percent of the funding pool that will be used to fund measures that save electricity vs. natural gas, the cost of saved electricity and natural gas, the average loan amount per building and the average loan payback period were made. The number of homes and buildings that could be reached by the policy in the first year was calculated by dividing the funding pool by the average loan amount per home or building. The number of homes and buildings that could be reached in subsequent years was calculated by dividing the amount of funds that were repaid in that year by the average loan amount per home or building. The energy savings were calculated by breakout out the funding pool into funds for electricity vs. natural gas measures and multiplying these pools by the energy savings per dollar spent in the first year on electricity and natural gas measures, respectively. Greenhouse gas emission reductions were calculated using emissions factors for each fuel type. The avoided costs by fuel type were also calculated.

Costs:

Assumptions about the difference between the interest rates for the government and participants were developed. The government interest was calculated by multiplying the full loan amount by the interest rate for the government for each year. The participant interest was calculated by multiplying the loan that had not been paid off by the participant interest rate for each year. The cost was calculated as the sum of the interest the government is paying on the loan, plus the total loaned amount. The loan amount was calculated as the total amount lent out over the entire period (because the loan was "re-lent" as is was repaid, subsequent "lending" of the same money were counted).

Key Assumptions:

100% of the fund is lent out to participants in the first year. As soon as the participant repays the loan, those funds are immediately lent out to another participant.

The interest is calculated at the end of each year based on the simple assumption that all of the funds are lent out and paid back at the beginning of each year. No corrections for mid-year transactions have been made. The interest was compounded over time.

Default risk, though more likely when working specifically with low-income populations, was not assessed in this analysis.

Benefits:

Table F-8 presents the key assumptions for the potential benefits from this policy.

Table F-8. Key assumptions for benefits from RCI-3

Assumption	Residential Sector	Commercial Sector	Notes
Loan fund	$50,000,000	$25,000,000	Placeholder assumption
Loan payback period	5 years	10 years	Placeholder assumption
Percent fund allocated to electricity vs. natural gas measures	68%		Based on Maryland electricity and natural gas revenues across all sectors
BBtu's saved per $ spent on electricity measures	0.01 MMBtu/$		Based on experience from Maryland and other states
BBtu's saved per $ spent on natural gas measures	0.04 MMBtu/$		Based on experience from other states
Proportion of energy savings by fuel type, emissions factors,T&D electricity loss, and avoided energy costs	Same assumptions as used for RCI-1.		

BBtu = billion British thermal units; MMBtu = million British thermal units; RCI = Residential, Commercial, and Industrial.

Costs:

Table F-9 presents the key assumptions for the potential costs of this policy.

Table F-9 Key assumptions for costs of RCI-3

Assumption	Residential Sector	Commercial Sector	Notes
Real discount rate	Same assumptions as used for RCI-1.		
Government interest rates	4.00%	4.00%	Used for all government policies
Participant interest rates	2.00%	2.00%	Placeholder assumption

RCI = Residential, Commercial, and Industrial.

Key Uncertainties

Many of the assumptions in this analysis are targets rather than being based on actual data from an existing program and are therefore uncertain, including

- The amount of the loan fund,
- The average loan payback period, and
- The amount of electricity and natural gas savings that can be achieved per dollar spent.

Appropriation(s) must be made for establishing the fund. The source of these funds is uncertain. Moreover, the rate at which private funding will be available is uncertain, especially if default risk is high.

Additional Benefits and Costs

- Indoor comfort and air quality improvements, with related improvements in health and productivity.
- Savings to consumers and business on energy bills. Benefits to the low income by reducing utility costs.

- Electricity system benefits: reduced peak demand, reduced capital and operating costs, improved utilization and performance of electricity system.
- Reduced risk of power shortages.
- Reduced pollutants from emissions, improved health from fewer pollutants and particulates, and reduced water use for cooling.
- Green-collar employment expansion and economic development.
- Reduced dependence on imported fuel sources.
- Reduced energy price increases and volatility.

Feasibility Issues

Default risk may be an issue if low-income populations are targeted.

Status of Group Approval

Approved.

Level of Group Support

Unanimous.

Barriers to Consensus

Not applicable.

RCI-4. Improved Design, Construction, Appliances, and Lighting in New and Existing State and Local Government Buildings, Facilities and Operations: "Government Lead-by-Example"

Policy Description

The State of Maryland and municipal and county governments can provide leadership in moving the state forward by adopting policies that improve the energy efficiency of new and renovated public buildings, facilities and operations. Recognizing that governments should "lead by example" the option presented here provides energy use targets to improve the efficiency of energy use in new and existing State and local government buildings, facilities and operations. The proposed policy provides energy efficiency targets that are much higher than code standards for new state-funded and other government buildings, facilities and operations. This option sets energy-efficiency goals for the existing government building stock, as well as for new construction and major renovations of government buildings, facilities and operations.

The following are elements of this policy:

- Government buildings, facilities and related operations (including wastewater and water utilities) will be in operation for many years and should be designed in a manner that meets or exceeds private sector mandated building and trade energy efficiency. Energy savings measures can pay for themselves through reductions in energy costs and improvements in workforce efficiency over the lifetime of the structure. All new State buildings and facilities, and renovations and additions shall be LEED certified at the Platinum level, or certified to a comparable standard, and meet or exceed the energy efficiency and renewable energy goals below stated.
- Participation in LEED-EB or a comparable standard would be encouraged or required for government buildings and facilities to ensure continued high performance through proper building operations and maintenance.
- Existing State and local government buildings shall be retrofitted for energy efficiency achieving 100% of cost-effective energy efficiency by the year 2015. To meet this goal, the State and local governments shall benchmark all buildings and facilities within the next 3 years.
- Establishment of energy performance and operations baselines for both new and existing State and other government buildings, followed by audits of these buildings. Audit results could be used to target and prioritize investments in improving government building energy efficiency.
- Improvement and review of efficiency goals over time, and development of flexibility in contracting arrangements to encourage integrated energy-efficient design and construction.
- Recommendations that the infrastructure for implementation (e.g., meters, accounting systems, staff) be established as soon as possible.

- Establishment of "retained savings" policies whereby government agencies are able to retain funds saved by reducing energy bills for further energy efficiency/renewable energy investments or other uses.
- Requirement of carbon-neutral bonding for new construction and renovations and additions. A carbon-neutral performance standard will require architects and engineers to design buildings to meet a climate-neutral requirement and built to meet or exceed the state's existing sustainable building guidelines and will save the taxpayers money as life-cycle costs will yield lower operational costs.
- Focus incentives on specific technologies, including white roofs, rooftop gardens, and landscaping to lower electricity demand, and solar photovoltaics to provide electricity when demand in highest.

Potential supporting measures for this option include training and certification of building sector professionals but could also include surveys of government energy and water use, energy benchmarking, measurement, and tracking programs for municipal and state buildings.

Policy Design

Goals:

Reduce per-unit-floor-area consumption of carbon-based electricity by 15% by 2010, 50% by 2020 and 100%, carbon neutral, by 2030, for government owned and leased buildings. These goals can be made by a combination of demand reduction measures, on-site carbon-neutral generation and grid based green power purchases. Green power purchases shall exceed the amount of green power purchases already provided by the utility

Timing: See above.

Parties Involved: State and local governments; MML and MACo; PSC; Maryland State Contractors association and related private contractor and materials and supply providers; Environmental Advocacy Organizations; MEA; DGS; Maryland Department of Transportation (MDOT); the University System, St. Mary's College, and Morgan State University.

Implementation Mechanisms

Mandates on Efficiency of Government-Owned Buildings, Including Schools and Publicly Owned Hospitals:

- New construction for which permits are requested between 2013 and 2020 will be required to meet LEED Platinum or a comparable standard;
- Buildings undergoing major renovations for which permits are requested between 2009 and 2013 will be required to meet LEED Gold or a comparable standard; and
- Buildings undergoing major renovations for which permits are requested between 2013 and 2020 will be required to meet LEED Platinum or a comparable standard.

Consider Innovative Financing: Matthew Brown (former Energy Policy Director with National Council for State Legislature, currently working for Governor Ritter of Colorado on energy efficiency and renewable energy financing) offered some thoughts about how public money could be used to keep financing costs and risks to a minimum. More benefits could be achieved, at potentially similar financing costs, using these principles:

- Incoming cash flow or dedicated funds (e.g. RGGI allowance revenues) can be used as leverage to buy down interest rates by providing a loss reserve (i.e., collateral for a loan, which can bring down interest rates by 2% or more), while at the same time earning interest for the state.
- Incoming cash flow or dedicated funds can also provide support for low-cost bonds. With this strategy, it is important not to have to "call" on funds.
- Leveraging private capital can expand the options open to public entities. Public-private financing is a fairly new and developing area, and existing business models are diverse. However, there is a large amount of interest and capital being considered for such investments (for example, Bank of America is financing $20 billion, mostly for renewable energy, but it includes generic "green" investments that could definitely be energy efficiency). Private investment will generally require a higher rate of return than secured public financing, but the private rate will not necessarily be higher than the rate of return on public, unsecured debt. If backed by public dollars to buy down the rate and establish a loss reserve, private funding could have a low rate.

Collect Data on State and Local Government Building and Facilities Energy Use: A key implementation mechanism for this option will be to first provide a thorough assessment of the status and energy consumption of all existing State and local government buildings, including establishing a database of buildings and building attributes including floor area, insulation level, energy-using equipment, and history of energy consumption. This baseline, or "carbon footprint," will be used to assess program success.

Benchmark State Buildings: Benchmarking is a process of using the data on building size, use, and energy use to quickly compare a building against others of similar size and use to get an idea of how efficiently the building is operating. It is an important step in identifying opportunities for savings and prioritizing work to be done.

Commission State Buildings: Building commissioning is a process of reviewing and tuning up the operation of building systems and controls much like the tune-up of a vehicle. Potential targets for commissioning might include commissioning of state buildings upon completion of construction or renovation and whenever the energy use in a building shows an unexpected and unexplained increase in energy use.

Purchase Green Power: Enter into agreements to purchase green power for a portion of the states electricity needs. Increase purchases over time until 100% of power needs are met through direct use of renewable energy or green power purchased by 2030.

Energy Use Targets: Set targets for energy use in the operation of state buildings, potentially including capping state and local building and facilities energy use per square foot. Motion sensors are a specific technology for reducing lighting energy use in government buildings that may have broad application in Maryland.

Renovate State and Local Buildings and Facilities Through a Buildings and Facilities Energy Program: Renovate all state and local buildings and facilities with more than 5,000 square feet and smaller buildings identified through energy benchmark process as having a high potential for energy savings within 5 years. The State and locals buildings and facilities energy program will provide funds for energy audits, engineering analyses, and renovation costs.

Develop and Use Renewable Energy Resources: Evaluate the potential for direct use of solar, wind, biomass, geothermal, and hydro power to meet the needs of state government operations. Take advantage of these renewable resources whenever it is cost-effective to do so, and as a means to lead by example in investing in these systems when it is practical to do so.

Carbon-Neutral Bonding: Climate-neutral bonding will require that any building projects financed with the issuance of state, county, or local/municipal bonds result in no net increase in GHG emissions. If a new construction project is projected to result in an emissions increase, there must be GHG emissions offsets within the state or particular jurisdiction. Offsets could include onsite renewable energy development, renewable energy purchases, energy efficiency (in existing state buildings), carbon sequestration (tree planting), and switching to cleaner or renewable fuels. Any GHGs emitted after the bond-financed project becomes operational will have to be offset. The new buildings could also offset their emissions by purchasing renewable electricity from their local utility. Paying a premium for what is known as "green pricing" electricity will usually be a more expensive offset option than energy efficiency. A community or state could install their own renewable energy project as a way to offset heir GHG emissions.

Monitoring and Verification: conduct periodic reviews of building energy use over time.

Related Policies/Programs in Place

- Maryland State Buildings Council Program to set energy efficiency programs for State buildings.
- State buildings required to reduce energy use by 15% by 2015 per the EmPOWER Maryland goal, set by Governor O'Malley in July 2007.
- Montgomery County Government and Board of Education, Bill 17-06 and Green School Focus.
- In April 2008, the legislature passed SB 208, consistent with Maryland Green Building Council recommendations for a high performance green building program. SB 208 requires capital projects that are funded solely with state funds for the construction or major renovation of buildings 7,500 square feet or greater to meet standards for a high performance building (as defined in the legislation), unless a waiver is granted. Because of when this legislation was passed, it has not been reflected in the analysis of RCI-4 that follows.
- Title V of the Energy Independence and Security Act of 2007 targets energy savings in government and public institutions.

Type(s) of GHG Reductions

Reduction in GHG emissions (largely CO_2) from avoided electricity production or on-site fuel combustion.

Estimated GHG Reductions and Net Costs or Cost Savings

Table F-10 presents the estimated GHG reductions and net costs or costs savings from implementing RCI-4.

Table F-10. Estimated GHG reductions and net costs of or cost savings from RCI-4

	GHG Reductions ($MMtCO_2e$)			Gross Costs (Million $)	Gross Benefits (Million $)	Net Present Value 2008–2020 (Million $)	Cost-Effective-ness ($/tCO_2e$)
	2012	2020	Total 2008–2020				
RCI–4 Total	**0.2**	**1.3**	**6.4**	**$147**	**–$484**	**–$337**	**–$53**
Government Buildings	0.2	1.1	5.6	$130	–$425	–$295	–$52
Schools	0.0	0.2	0.8	$17	–$60	–$42	–$54

GHG = greenhouse gas; $MMtCO_2e$ = million metric tons of carbon dioxide equivalent; $/$tCO_2e$ = dollars per metric ton of carbon dioxide equivalent.

Data Sources:

- U.S. Energy Information Administration, Commercial Buildings Energy Consumption Survey (CBECS), http://www.eia.doe.gov/emeu/cbecs/

For Government Buildings and Schools

- M. A. Halverson, K. Gowri, and E. E. Richman of Pacific Northwest National Laboratory. "Analysis of Energy Saving Impacts of New Commercial Energy Codes for the Gulf Coast", December 2006, http://www.energycodes.gov/pdf/pnnl16282.pdf (accessed January 6, 2008).
- Incremental Costs from WBCSD, "Energy Efficiency in Buildings: Summary Report," October 2007.
- Greg Katz and Jon Braman. Greening Buildings and Communities: Costs and Benefits. Draft Findings on the Cost Premium, Energy and Water Savings by LEED Level. 2008. (unpublished, under review).
- ICC Code Website. Building Valuation Data. http://www.iccsafe.org/cs/techservices/ (accessed March 13, 2008).

Additional Resources For Schools

- Statistics found at http://maryland.schooltree.org/counties-page1.html and http://www.heritage.org/research/Education/SchoolChoice/Maryland.cfm.
- Forefront Economics, Inc., H. Gil Peach & Associates LLC, and PA Consulting Group. "Duke Energy Carolinas DSM Action Plan: South Carolina Draft Report." July 24, 2007.

Quantification Methods:

Benefits:

First, separate ramp ins for energy savings by existing and new buildings were developed to together meet the overall energy savings goal and defined an overall energy savings ramp in. Then, the number of existing and new building participants was calculated. Energy savings were developed using the energy savings ramp ins and the number of building participants. After the energy savings were broken out by fuel type, the greenhouse gas emission reductions were calculated using emissions factors for each fuel type. The avoided costs by fuel type were also calculated.

Costs:

Incremental cost trajectories were developed independently for existing and new buildings based on the energy savings trajectories. For existing buildings this was calculated using a bottom up approach by estimating the cost of specific measures to achieve the first level of energy savings and scaling these costs according to the energy savings trajectory. For new buildings this was calculated using a top down approach by determining the cost to build the building and using a percentage to back out the incremental costs of outfitting it with beyond-code measures. Then, the incremental cost for the first level of energy savings was scaled according to the energy savings trajectory. The incremental cost per building was multiplied by the number of participants to determine the overall costs.

Key Assumptions:

The analysis of costs and GHG benefits was limited to energy efficiency measures. Alternative means of reaching the goals (switching to low and no carbon-based fuels for previously carbon-based end-uses, off-site purchases on grid supplied "green power" and/or installing on-site off-grid power generating equipment) were not modeled.

Schools were included in this analysis as requested by TWG members.

It was assumed that the number of commercial government buildings from CBECS did not include schools although this could not be confirmed.

Due to lag times associated with the design and permitting for new buildings, it was assumed that a new build process initiated in 2009 will incur costs immediately but will not result in energy savings until 2013.

For Government Buildings and Schools

Table F-11 shows the assumed energy savings ramp in to achieve the total energy savings goal.

Table F-11. Energy savings trajectory for RCI-4 for new and existing buildings, government buildings and schools

Year	Energy Savings from Existing Buildings	Notes on Existing	Energy Savings from New Buildings	Notes on New
2009	15%	Code (15%)	0%	No savings due to design-completion time lag
2010	15%	Code (15%)	0%	As above
2011	15%	Code (15%)	0%	As above
2012	15%	Code (15%)	0%	As above
2013	15%	Code (15%)	50%	LEED Platinum
2014	30%	ENERGY STAR Standard (15% + 15%)	50%	LEED Platinum
2015	30%	ENERGY STAR Standard (15% + 15%)	50%	LEED Platinum
2016	30%	ENERGY STAR Standard (15% + 15%)	50%	LEED Platinum
2017	40%	LEED Certification/Silver (15% + 25%)	50%	LEED Platinum
2018	40%	LEED Certification/Silver (15% + 25%)	50%	LEED Platinum
2019	40%	LEED Certification/Silver (15% + 25%)	50%	LEED Platinum
2020	50%	LEED Silver/Gold (15% + 35%)	50%	LEED Platinum

LEED = Leadership in Energy and Environmental Design Green Building Rating System.

For Government Buildings

Table F-12 presents the assumed incremental cost trajectory based on the energy savings.

Table F-12. Incremental cost trajectory for RCI-4—government buildings

Year	Energy Savings from Existing Buildings	Assumed Incremental Cost for Existing Buildings	Energy Savings from New Buildings	Assumed Incremental Cost for New Buildings
2009	15%	$16,182	0%; No savings due to design-completion time lag	4.0% increase
2010	15%	$16,182	0% (as above)	4.0% increase
2011	15%	$16,182	0% (as above)	4.0% increase
2012	15%	$16,182	0% (as above)	4.0% increase
2013	15%	$16,182	50%	4.0% increase
2014	30%	$16,182 × 2.0	50%	4.0% increase
2015	30%	$16,182 × 2.0	50%	4.0% increase
2016	30%	$16,182 × 2.0	50%	4.0% increase
2017	40%	$16,182 × 2.7	50%	4.0% increase
2018	40%	$16,182 × 2.7	50%	4.0% increase
2019	40%	$16,182 × 2.7	50%	4.0% increase
2020	50%	$16,182 × 3.3	50%	4.0% increase

Benefits: Table F-13 presents the key assumptions for the potential benefits of the government buildings component of this policy.

Table F-13. Key assumptions for benefits from RCI-4—government buildings

Assumption	Existing Buildings	New Buildings	Notes
Average square footage per building	26,453		From CBECS
Number of buildings	21,348	2,102	Existing: As of the end of 2008 New: 2009–2020
Reach	50%	100%	Placeholder assumption
Average energy use	0.00008 BBtu/sq. ft./year	0.00007 BBtu/sq. ft./year	Calculation of energy use divided by projected number of homes/buildings
Ratio of commercial to government energy use per sq. ft.	1.00		Placeholder assumption
Current stock vs. new stock energy savings	16%		Calculated using Gulf Coast studies on building codes
Proportion of energy savings by fuel type, emissions factors, T&D electricity loss, avoided energy costs	Same assumptions as used for RCI-1.		

CBECS = Commercial Buildings Energy Consumption Survey; BBtu = billion British thermal units; sq. ft. = square feet; T&D = transmission and distribution; RCI = Residential, Commercial, and Industrial

Costs: Table F-14 presents the key assumptions for the potential costs of the government buildings component of this policy.

Table F-14. Key assumptions for costs of RCI-4—government buildings

Assumption	Existing and New Buildings	Notes
Real discount rate	Same assumptions as used for RCI-1.	
Capital recovery factor for levelization	5.6% Interest Rate: 4% Period: 30 years	Calculated assumption
Average construction cost of a building	$3,458,708	Based on national estimates from the International Code Council (ICC)

RCI = Residential, Commercial, and Industrial.

For Schools

Table F-15 presents the assumed incremental cost trajectory based on the energy savings from school buildings.

Table F-15. Incremental cost trajectory for RCI-4—schools

Year	Energy Savings from	Assumed Incremental Cost for Existing Buildings	Energy Savings from New Buildings	Assumed Incremental Cost for New Buildings

	Existing Buildings			
2009	15%	$14,783	0%; No savings due to design lag	4.0% increase
2010	15%	$14,783	0%; No savings due to design lag	4.0% increase
2011	15%	$14,783	0%; No savings due to design lag	4.0% increase
2012	15%	$14,783	0%; No savings due to design lag	4.0% increase
2013	15%	$14,783	50%	4.0% increase
2014	30%	$14,783 × 2.0	50%	4.0% increase
2015	30%	$14,783 × 2.0	50%	4.0% increase
2016	30%	$14,783 × 2.0	50%	4.0% increase
2017	40%	$14,783 × 2.7	50%	4.0% increase
2018	40%	$14,783 × 2.7	50%	4.0% increase
2019	40%	$14,783 ×2.7	50%	4.0% increase
2020	50%	$14,783 × 3.3	50%	4.0% increase

Benefits: Table F-16 presents the key assumptions for the potential benefits of the schools component of this policy.

Table F-16. Key assumptions for benefits from RCI-4—schools

Assumption	Existing Buildings	New Buildings	Notes
Average square footage per building	34,995		From analysis of South Carolina by CCS
Number of buildings	2,267	238	Existing: As of the end of 2008 New: 2009–2020
Reach	50%	100%	Placeholder assumption
Average energy use	0.00008 BBtu/sq. ft./year	0.00006 BBtu/sq. ft./year	Calculation of energy use divided by projected number of homes/buildings
Ratio of commercial to school energy use per sq. ft.	1.00		Placeholder assumption
Current stock vs. new stock energy savings	23%		Calculated using school-specific data from Gulf Coast studies on building codes
Proportion of energy savings by fuel type, emissions factors, T&D electricity loss, avoided energy costs	Same assumptions as used for RCI-1.		

BBtu = billion British thermal units; sq. ft. = square feet; T&D = transmission and distribution; RCI = Residential, Commercial, and Industrial.

Costs: Table F-17 presents the key assumptions for the potential costs of the schools component of this policy.

Table F-17. Key assumptions for costs of RCI-4—schools

Assumption	Existing and New Buildings	Notes
Real discount rate	Same assumptions as used for RCI-1.	
Capital recovery factor for levelization	Same assumptions as used for government buildings	
Average construction cost of a building	$5,027,732	Based on national estimates from the International Code Council (ICC)

RCI = Residential, Commercial, and Industrial.

Key Uncertainties

The following are assumptions for which there were little or no supporting data:

- The percentage of existing and new buildings that can be effectively reached with this policy,
- The ratio between average commercial building energy use and government or school building energy use, and
- The incremental cost to renovate existing government buildings to achieve beyond-code energy savings.

Additionally, the cost of new construction is based on national estimates. Region-specific estimates may be either higher or lower than these costs.

Additional Benefits and Costs

- With any lead-by-example policy, the intent is that state employees will become interested in implementing the types of energy savings measures they are exposed to at work in their own commercial buildings and/or residential homes. Another way that this initiative can spread is through word of mouth to the employees friends and family. (This policy analysis did not include a quantification of this additional benefit.) See CC-4.
- Indoor comfort and air quality improvements, with related improvements in health and productivity.
- Savings on energy bills.
- Electricity system benefits: reduced peak demand, reduced capital and operating costs, improved utilization and performance of electricity system.
- Reducing the risk of power shortages.
- Reducing pollutants from emissions, improved health from fewer pollutants and particulates and reduced water use for cooling.
- Green collar employment expansion and economic development.
- Reducing dependence on imported fuel sources.

- Reducing energy price increases and volatility.

Feasibility Issues

Will require state to provide resources.

Status of Group Approval

Approved.

Level of Group Support

Unanimous.

Barriers to Consensus

Not applicable.

RCI-5. Energy Efficiency and Environmental Impacts Awareness and Instruction in School Curricula

Jointly considered with the CC TWG. See CC-5.

RCI-6. Promotion and Incentives for Improved Design and Construction (e.g., LEED, Green Buildings, or Minimum Percent Improvement Better Than Code) in the Private Sector

Combined with RCI-1.

RCI-7. More Stringent Appliance/Equipment Efficiency Standards (State-Level, or Advocate for Regional or Federal-Level Standards)

Policy Description

Appliance efficiency standards reduce the market cost of energy efficiency improvements by incorporating technological advances into base appliance models, thereby creating economies of scale. Appliance efficiency standards can be implemented at the state level for appliances not covered by federal standards, or where higher-than-federal standard efficiency requirements are appropriate. Regional coordination for state appliance standards can be used to avoid concerns that retailers or manufacturers may either resist supplying equipment to one state that has advanced standards, or focus sales of lower efficiency models on a state with less stringent efficiency standards.

There are federal standards for 19 residential products and 19 pieces of commercial equipment, as well as 14 lighting standards. Laws require the U.S. Department of Energy (DOE) to set minimum appliance efficiency standards that are technologically feasible and economically justified. However, there are many appliances not covered by federal standards for which state standards can play a role.

This policy option includes

- Lobbying for more stringent appliance standards at the federal level,
- Establishment and enforcement of higher-than-federal state-level appliance and equipment standards (or standards for devices not covered by federal standards), and
- Joining with other states in adopting higher standards.

Consumer education is an important supporting measure for this option.

Policy Design

Goals: State minimum efficiency standards for appliances not covered by federal standards as recommended by Appliance Standards Awareness Program[1] by 2009.

Timing: As noted above.

Parties Involved: As noted above.

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[1] See http://www.standardsasap.org/documents/a062_sc.pdf. The analysis recommends standards for the following products: bottle-type water dispensers, commercial boilers, commercial hot food holding containers, compact audio products, DVD players and recorders, liquid immersion distribution transformers, medium voltage dry-type distribution transformers, metal halide lamp fixtures, pool heaters, portable electric spas, residential furnaces and boilers, residential pool pumps, single voltage external AC-to-DC power supplies, state regulated incandescent reflector lamps, and walk-in refrigerators and freezers.

Implementation Mechanisms

Appliance Standards can be promulgated by legislation or developed administratively.

Appliances covered by the Appliance Standards Awareness Program (ASAP) are updated annually to incorporate the effects of new state and federal appliance standards. Review and adoption of updated ASAP-recommended state-level appliance standards should be undertaken periodically (e.g., every 3 years or as new federal standards are enacted).

It is recommended that the state work with manufacturers and consider impacts on manufacturers when setting new standards.

Manufacturers shall be required to keep spare parts for existing appliances for a specified number of years, if mandated by and consistent with federal regulation.

Related Policies/Programs in Place

Maryland Energy Efficiency Standards Act (became law per Maryland Constitution, Chapter 2 of 2004 on January 20, 2004): Maryland standards apply to nine appliances: Torchiere lighting fixtures; unit heaters; low-voltage, dry-type distribution transformers; ceiling fans and ceiling fan light kits; red and green traffic signal modules; illuminated exit signs; commercial refrigeration cabinets; large packaged air conditioning equipment; and commercial clothes washers. Standards become effective in March 2005. The exceptions to this general rule relate to commercial clothes washers, and ceiling fan light kits. Commercial clothes washers and ceiling fan light kits do not have to meet the new efficiency standards until March 1, 2007. Commercial clothes washers and ceiling fan light kits not meeting the standards may be installed until January 1, 2008. There is no overlap between the appliances covered by this Act and the appliances recommended by the 2006 Appliance Standards Awareness Program.

Maryland Energy Efficiency Standards Act of 2007: Before January 1, 2008 the MEA shall adopt regulations establishing minimum efficiency standards for the following types of new products: Bottle-type water dispensers; commercial hot food holding cabinets; metal halide lamp fixtures; residential furnaces and furnace fans in new construction; single-voltage external alternating current (AC) to direct current (DC) power supplies; state-regulated incandescent reflector lamps; walk-in refrigerators and freezers. All of the appliances from this act are included in the appliances recommended by the 2006 Appliance Standards Awareness Program. However, the standards for all of these appliances, except for bottle-type water dispensers, and commercial hot food holding cabinets will be superseded by the federal Energy Independence and Security Act of 2007. Compact audio products and digital video disk (DVD) players and recorders were also included in the original bill, but removed before the bill became law.

Energy Independence and Security Act of 2007: This federal law establishes new minimum efficiency standards for several appliance types, including five that are also recommended by the 2006 Appliance Standards Awareness Program: residential boilers; state-regulated incandescent reflector lamps; single-voltage external alternating current AC to DC power supplies; metal halide lamp fixtures; and walk-in refrigerators and freezers. There are also provisions in this Act for future residential furnace and furnace fan standards. This legislation will supersede the standards established in the Maryland Energy Efficiency Standards Act of 2007, where applicable.

Type(s) of GHG Reductions

Reduction in GHG emissions (largely CO_2) from avoided electricity production or on-site fuel combustion.

Estimated GHG Reductions and Net Costs or Cost Savings

Table F-18 presents the estimated GHG reductions and net costs or costs savings from implementing RCI-7.

Table F-18. Estimated GHG reductions and net costs of or cost savings from RCI-7

	GHG Reductions ($MMtCO_2e$)			Gross Costs (Million $)	Gross Benefits (Million $)	Net Present Value 2008–2020 (Million $)	Cost-Effective-ness ($/tCO_2e$)
	2012	2020	Total 2008-2020				
RCI–7	0.1	0.2	1.2	$18	–$81	–$63	–$54

GHG = greenhouse gas; $MMtCO_2e$ = million metric tons of carbon dioxide equivalent; $/$tCO_2e$ = dollars per metric ton of carbon dioxide equivalent.

Data Sources:

- U.S. Congress. House. *Energy Independence and Security Act of 2007*. H.R.6. 110th Cong., 1st sess.
- *Maryland Energy Efficiency Standards Act*, Annotated Code of Maryland, sec. 9-2006 2004.
- *Maryland Energy Efficiency Standards Act of 2007*, Annotated Code of Maryland, sec. 9-2006, 2007.
- Center for Integrative Environmental Research, University of Maryland, College Park 2007. Economic and Energy Impacts from Maryland's Potential Participation in the Regional Greenhouse Gas Initiative: A Study Commissioned by the MDE, available at http://www.cier.umd.edu/RGGI/.
- Nadel, Steven, Andrew deLaski, Maggie Eldridge, and Jim Kleisch. Leading the Way: Continued Opportunities for New State Appliance and Equipment Efficiency Standards, ASAP and ACEEE, Report Number ASAP-6/ACEEE-A062, March 2006.
- Nadel, Steven, Andrew deLaski, Maggie Eldridge, and Jim Kleisch. Energy Efficiency Standards Benefits – 2006 Model Bill: Maryland, ASAP and ACEEE, http://www.standardsasap.org/documents/a062_md.pdf (accessed December 7, 2007).
- Prindle, Bill. Energy Efficiency in Maryland's Electricity Future. American Council for an Energy-Efficient Economy, ACEEE Report Number E077, September 2007.

Quantification Methods:

- Energy savings are quantified for the following appliances, as recommended by ASAP: commercial boilers, compact audio products, DVD players and recorders, liquid-immersed distribution transformers, medium voltage dry-type distribution transformers, pool heaters, portable electric spas (hot tubs), and residential pool pumps.
- Projected electricity and natural gas savings are taken from the 2006 Appliance Standards Awareness Program data for Maryland for the appropriate appliances not already covered by the Maryland Energy Efficiency Standards Act and the federal Energy Independence and Security Act of 2007.
- These annual energy savings are adjusted to fit the analysis period, per ramp rate of appliances and target implementation year.
- The appropriate GHG emissions factors, energy prices, and discount rate are applied.

Key Assumptions:

- Costs and savings from efficiency improvement via standards are similar in Maryland to those indicated in the ASAP/ACEEE report.
- It is assumed that development and manufacturing lead time for bringing appliances that meet ASAP standards to market is minimal, because most of the appliances identified by ASAP are subject to efficiency standards in other states (http://www.standardsasap.org/state.htm). Consistent with ASAP assumptions, appliances are assumed to be available starting in 2009, except for commercial boilers, distribution transformers, and pool heaters, which are assumed to be available as of 2010, 2010, and 2013 respectively.
- *Capital Recovery Factor:* 10.27%, consistent with a 5.25% interest rate (average of commercial and residential rates) and 13 year asset life

Key Uncertainties

It is unknown the degree to which other states in the region will join with Maryland in setting higher-than-federal standards so as to increase effectiveness and practical application of standards.

New federal standards may be enacted before 2020 that would minimize the projected energy savings from these appliances.

Savings from efficiency standards for residential furnaces and furnace fans in the Maryland Energy Efficiency Standards Act of 2007 (MEESA) may be overstated. In its analysis of the final bill, ACEEE assumed a 1:1 ratio of the benefits from new construction to retrofits to adjust for a late-coming amendment excluding retrofits from the standard. This may have overstated the benefits of MEESA. As this policy analysis builds on the ACEEE analysis, RCI-7 may have larger benefits from furnace and furnace fans in retrofits.

Additional Benefits and Costs

- Reduction in water use for some appliance upgrades – lower water demand leads to lower costs and reduced energy use for water production. In the City of Annapolis, water utility and sewer pumps account for around 23% of energy use and 30% of CO_2e emissions.
- Indoor comfort and air quality improvements, with related improvements in health and productivity.
- Savings to consumers and business on energy bills. Benefits to the low income by reducing utility costs.
- Electricity system benefits: reduced peak demand, reduced capital and operating costs, improved utilization and performance of electricity system.
- Reduced pollutants from emissions, improved health from fewer pollutants and particulates and reduced water use for cooling.
- Reduced dependence on imported fuel sources.
- Reduced energy price increases and volatility

Feasibility Issues

The feasibility of this policy option is enhanced by ongoing efforts in nearby states and at the federal level.

Status of Group Approval

Approved.

Level of Group Support

Unanimous.

Barriers to Consensus

Not applicable.

RCI-8. Rate Structures and Technologies to Promote Reduced GHG Emissions (Including Peak Pricing and Inverted Block Surcharge)

Policy Description

This option could include various elements of utility rate design that are geared toward reducing greenhouse gas emissions, often with other benefits as well, such as reducing peak power demand. The overall goal is to revise rate structures so as to better reflect the actual economic and environmental costs of producing and delivering electricity as those costs vary by time of day, day of the week, season, or from year to year. In this way, rates provide consumers with information reflecting the impacts of their consumption choices.

Potential elements of this option include:

- Tiered (increasing/inverted block) surcharges on electricity transmission and distribution (T&D) charges, which keep base usage rates affordable but increase with increasing consumption. Similarly, inverted block rates for natural gas use may be considered.
- Time-of-use rates, which typically price electricity higher at times of higher power demand, and thus better reflect the actual cost of generation. Time-of-use rates may or may not have a significant impact on total GHG emissions, but do affect on-peak power demand and thus both the need for peaking capacity and fuel for peaking plants.
- "Smart metering"—implementation of consumer meters showing real-time pricing, and the level of GHG emissions related to consumption at any given time.

Policy Design

Goals:

- Implement a 2 -tiered, inverted-block surcharge structure for all commercial and residential electricity customers, to be placed on electricity T&D charges. The cheapest tier should apply to a percentage of average consumption. The most expensive tier should apply to electricity use above average consumption and be priced high enough to encourage conservation. California may offer a good example of percentages and rates. The need for a low income exclusion from the program should be investigated.
- Replace traditional electricity meters with "smart meters" as meters otherwise need to be replaced. Time of use rates should be implemented in conjunction with the replacement of existing meters with smart meters.

Timing: The two-tiered surcharge system should be implemented for all utilities within 12 months. Conversion to smart meters should begin immediately but proceed slowly for many years. Once more cost-effective energy efficiency measures have been taken, proactive replacement of meters with smart meters should begin and expand.

Parties Involved: residential and commercial electricity customers, utilities, Maryland Office of People's Council (OPC), PSC, and MEA.

Implementation Mechanisms

A two-tiered surcharge, applicable to all residential and commercial customers, will be proposed by the utilities and approved by the PSC within 12 months. The revenues from this surcharge will be invested in DSM programs.

The need for a low income exclusion from the program should be investigated by the PSC.

Under a replacement schedule and cost recovery plan approved by the PSC, utilities will replace traditional electricity meters with “smart meters”. When their existing meters are replaced with smart meters, customers will be transferred to a time of use rate schedule.

Related Policies/Programs in Place

The Southern California Edison program, which included a low-income component, should be investigated.

AMI filings with the PSC (Case Number: 9111):

- Application of Potomac Electric Power Company for Authority to Establish a Demand-Side Management Surcharge, an Advance Metering Infrastructure (AMI) Surcharge and to Establish a DSM Collaborative and an AMI Advisory Group (ML# 105286), and
- Application of Delmarva Power & Light Company for Authority to Establish a Demand-Side Management Surcharge, an Advance Metering Infrastructure Surcharge and to Establish a DSM Collaborative and an AMI Advisory Group (ML# 105287).

Type(s) of GHG Reductions

Reduction in GHG emissions (largely CO_2) from avoided electricity production or on-site fuel combustion.

Estimated GHG Reductions and Net Costs or Cost Savings

Table F-19 presents the estimated GHG reductions and net costs or costs savings from implementing RCI-8.

Table F-19. Estimated GHG reductions and net costs of or cost savings from RCI-8

	GHG Reductions ($MMtCO_2e$)			Gross Costs (Million $)	Gross Benefits (Million $)	Net Present Value 2008–2020 (Million $)	Cost-Effective-ness ($/tCO_2e$)
	2012	2020	Total 2008–2020				
RCI–8 Total (assuming 0.5% savings from smart metering)	**0.1**	**0.2**	**2.0**	**$403**	**–$157**	**$246**	**$120**
Demand-side management surcharge – residential	0.0	0.0	0.3	$0	–$29	–$29	–$96
Demand-side management surcharge – commercial	0.0	0.0	0.1	$0	–$6	–$6	–$96
Smart metering:							
0.5% savings	0.1	0.2	1.7	$403	–$122	$281	$167
1.5% savings	0.2	0.7	5.1	$403	–$366	$37	$7
3.0% savings	0.4	1.3	10.1	$403	–$732	–$329	–$33

GHG = greenhouse gas; $MMtCO_2e$ = million metric tons of carbon dioxide equivalent; $/$tCO_2e$ = dollars per metric ton of carbon dioxide equivalent; RCI = Residential, Commercial, and Industrial.

Data Sources:

Price elasticity of electricity

- Energy Information Administration (EIA), Price Responsiveness in the *Annual Energy Outlook 2003 (*AEO2003) National Energy Modeling System (NEMS) Residential and Commercial Buildings Sector Models, available at www.eia.doe.gov/oiaf/analysispaper/elasticity/index.html and www.eia.doe.gov/oiaf/analysispaper/elasticity/table1.html

Electricity prices

- ACEEE et al. 2008. Maryland's Clean Energy Future Potential For Energy Efficiency And Demand Response To Meet Electricity Needs In Maryland

Distribution curve for electricity consumption

- EIA Residential Energy Consumption Survey (RECS) 2001, and
- EIA CBECS 2003.

Impacts of different types of smart metering

- "Smart Metering Study Summary" (smart-metering-append.pdf) compiled by CU Denver for the City and County of Denver.
- Summit Blue Consulting, Inc. 2006. Evaluation of the 2005 Energy-Smart Pricing PlanSM, prepared for Community Energy Cooperative, August 2006, available at www.energycooperative.org/pdf/ESPP-Evaluation-Executive-Summary-2005.pdf and www.energycooperative.org/energy-smart-pricing-plan.php.
- Primen, Inc. 2004. California Information Display Pilot Technology Assessment, www.ucop.edu/ciee/dretd/documents/idp_tech_assess_final1221.pdf.

Cost of metering

- Idaho Power 2005. Phase One AMR Implementation Status Report under IPC-E-02-12, December 30, 2005.
- CA PUC 2006. Advanced Metering Infrastructure (AMI) Update, available at www.cpuc.ca.gov/Static/hottopics/1energy/ami_update+june+2006.pdf.
- Demand Response and Advanced Metering Coalition (DRAM) 2004. White Paper: Overview of Advanced Metering Technologies and Costs, available at http://www.dramcoalition.org/id66.htm.
- Booz Allen Hamilton 2007. "Smart Grid – Opportunity Meets necessity," presented at the EEI Strategic Issues Forum in Miami, FL on February 7, 2007, available at http://www.eei.org/meetings/nonav_2007-02-07-ja/index.htm.

Metering deployment schedule

- The Brattle Group 2007. Quantifying Customer Benefit from Reductions in Critical Peak Loads from Pepco Holdings, Inc.'s (PHI's) Proposed Demand-Side Management Program, September 21, 2007.

Energy savings from smart metering

- International Business Machines (IBM) Global Business Services et al. 2007. Ontario Energy Board Smart Price Pilot Final Report, July 2007, available at http://www.oeb.gov.on.ca/html/en/industryrelations/ongoingprojects_regulatedpriceplan_smartpricepilot.htm.
- Summit Blue Consulting, LLC. 2007. Final Report for the MyPower Pricing Segments Evaluation, submitted to Public Service Electric and Gas Company, December 21, 2007.

Quantification Methods: This analysis consists of two major components: impact of inverted block rates and smart meters. The steps that would be required to estimate the impact of inverted block rates are as follows:

- Determine the focus of customer groups (i.e., residential and commercial).
- Determine two levels of surcharges that are applied to different levels of consumption thresholds (e.g., 3 mills per kWh above 830 kWh per month per household (or 10 megawatt [MW] per year) and 5 mills per kWh above 1420 kWh per month per household; 3 mills per kWh above 0.8 kWh per month per square foot of commercial floor space and 5 mills per kWh above 1.3 kWh per month per square foot).
- Develop distribution curves for electricity consumption by residential and commercial customers using the data available in EIA's RECS 2001 and CBECS 2003.
- Identify the total amount of consumption for three consumption groups (A, B, and C) where households in Group A consume less than the first threshold per year, households in Group B consume above the first threshold up to the second threshold per year, and households in Group C consumes above the second threshold.

- Identify the level of consumption for consumers in each group that is subject to each consumption threshold as a percentage of the total residential or commercial consumption. (e.g., the sum of the consumption levels for households in Group B that is not subject to surcharges is about 26% of the total residential consumption and the sum of the consumption levels that is subject to the first surcharge is about 22%).
- Apply the percentage of the total consumption subject to each surcharge to the total consumption in each year.
- Apply surcharges to appropriate consumption segments.
- Project change in electricity consumption based on price elasticity.
- Estimate energy savings and the associated economic benefit based on price elasticity.
- Estimate GHG emissions reduction from energy savings.

The second piece of this analysis for smart metering involves

- Developing a time schedule for replacing existing meters with smart meters,
- Estimating the cost and energy savings from deployment of smart meters through 2020, and
- Estimating GHG emissions reduction from energy savings.

Key Assumptions:

- *Rate design*—customers who install smart meters will be placed on Time-of-Use rates.
- *DSM surcharge*—3 mills per kWh above the first threshold (Group B) and 5 mills per kWh above the second threshold (Group C).
- *Distribution curve for residential electricity consumption*—We obtained regional average energy consumption from the EIA RECS 2001 and developed a distribution curve for Mid-Atlantic region with the following steps: assume all regional curves including Mid-Atlantic have the same standard deviation, and adjust the level of standard deviation so that the distribution curve that covers the entire United States would approximate a normal distribution. Table F-20 presents the fraction of total regional consumption for each residential grouping, and Table F-21 shows the level of household consumption subject to each surcharge for each residential consumption group.

Table F-20. Fraction of total regional consumption by residential grouping

Group A	13%
Group B	48%
Group C	39%
Total	**100%**

Table F-21. Level of household consumption subject to each surcharge as percentage of total residential consumption in each consumption group

	No Surcharge	1st Surcharge	2nd Surcharge	Total
Group A	13%	0%	0%	13%
Group B	26%	22%	0%	48%
Group C	13%	11%	15%	39%
Total	**53%**	**32%**	**15%**	**100%**

- *Distribution curve for commercial electricity consumption*—To estimate the impact of an increasing block rate structure on commercial electricity users, it was first necessary to estimate the distribution of energy consumption on a square foot basis in Maryland. Based on U.S. Census data, we determined that the per-square-foot energy consumption has a mean of 13.4 kilowatt per square foot (kW/sq-ft) per year. Lacking any basis to estimate the population-wide distribution of the data, we assumed that it can be approximated by a normal distribution with a standard deviation of 30% of the mean, or 4.02 kW/sq-ft per year. Given these parameters, we found that the bottom quartile uses 10 kW/sq-ft per year or less energy; while the top quartile uses 17 or more kw/sq foot annually. Thus this policy would impose no surcharge on the first ten kW/sq-ft, a first surcharge on the next six kw/sq-ft, and the maximum surcharge on all usage 17 kW/sq-ft or above. Based on the assumed distribution of use described above, we can then calculate the total annual kWh usage and the total surcharge recovered at each usage level. Table F-22 presents the fraction of total regional consumption for each commercial grouping in Maryland, and Table F-23 shows the level of consumption subject to each surcharge for each commercial consumption group.

Table F-22. Fraction of total commercial consumption by grouping

Group A	14%
Group B	54%
Group C	33%
Total	**100%**

Table F-23. Level of consumption subject to each surcharge as percentage of total commercial consumption in each group

	No Surcharge	1st Surcharge	2nd Surcharge	Total
Group A	14%	0%	0%	14%
Group B	40%	14%	0%	54%
Group C	17%	10%	5%	33%
Total	**71%**	**24%**	**5%**	**100%**

- *Consumption thresholds for residential customers*—the following thresholds are illustrative thresholds. Actual thresholds will change over time depending on the level of total consumption.
    - 1st threshold: 11,800 kWh per year or 980 kWh per month per household.

  - 2nd threshold: 15,700 kWh per year or 1308 kWh per month per household.

- *Consumption thresholds for commercial customers*—the following thresholds are illustrative thresholds. Actual thresholds will change over time depending on the level of total consumption.

  - 1st threshold: about 11 kWh per year or 0.92 kWh per month per square foot.
  - 2nd threshold: about 17 kWh per year or 1.4 kWh per month per square foot.

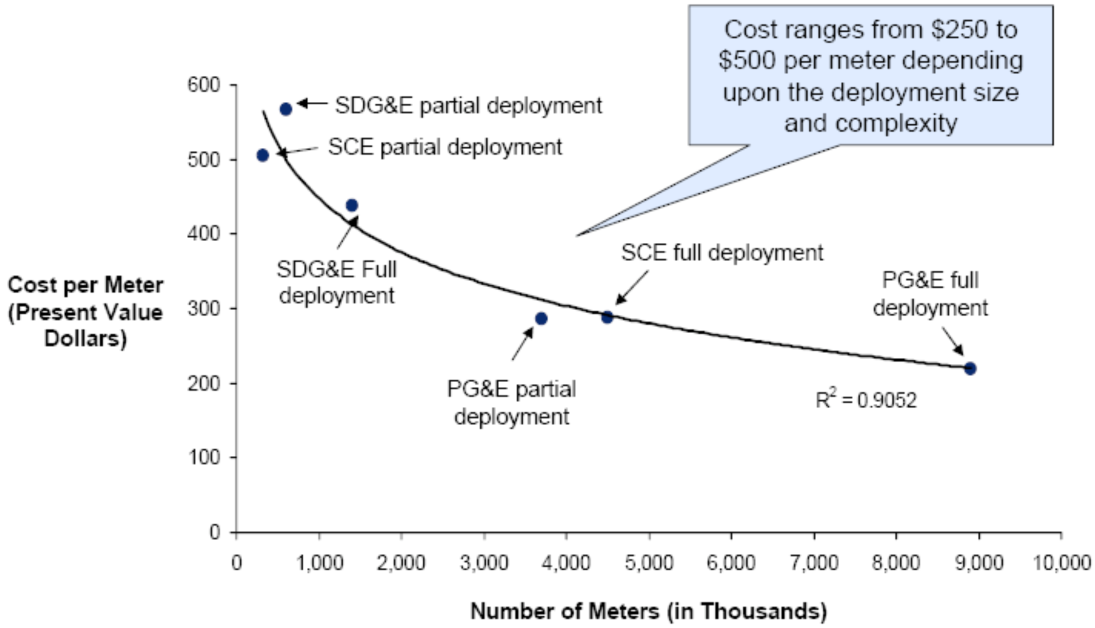
- *Schedule for replacing existing meters*—we assume a lead time of two years for planning, program designs, and selecting vendors and technologies before deploying smart metering. Deployment schedule is 6 years. We assume utilities start to deploy smart metering/advanced metering infrastructure (AMI) starting in 2011 and will fully deploy by 2016. After 2016, small numbers of meters are deployed to cover the new customers. This deployment schedule is longer than what has been proposed by utilities. For example, according to the Brattle Group (2007), Pepco and Delmarva Power & Light (DPL) in Maryland are planning to deploy AMI in three years. Also Pepco in Washington D.C. and DPL in Delaware are planning to fully deploy AMI in two years. Table F-24 presents the assumed schedule for replacing existing meters in all service territories in Maryland.

Table F-24. Schedule for replacing existing meters

Year	Share
2009	0%
2010	0%
2011	17%
2012	33%
2013	50%
2014	67%
2015	83%
2016	100%

- *Cost of smart meters (that are capable of having at least critical peak pricing) and in-home display*—$350 per smart meter system installed. Cost of smart metering/advanced metering systems (including interval meters, in-home displays, and meter data management system) ranges from $200 to $500 per meter depending upon the deployment size and complexity. This range is based on Idaho Power 2005, California Public Utilities Commission (CA PUC) 2006, Demand Response and Advanced Metering Coalition (DRAM) 2004, and Booz Allen Hamilton 2007. Figure F-1 from Booz Allen Hamilton (2007) presents cost of AMI deployments based on number of meters. We are assuming utilities will deploy approximately 2.8 million meters by 2020.

Figure F-1. Cost of AMI meters relative to number of meters deployed



Source: Booz Allen Hamilton 2007

- *Demand reduction from deployment of smart meters*—No existing studies estimate annual energy reduction as well as emission reductions from the time of use pricing that has been proposed recently including critical peak pricing. The studies on smart metering and critical peak pricing pilot projects in New Jersey and Ontario, Canada provide some useful, but limited experience on annual energy savings. Given the uncertainty regarding how much annual energy consumption and emissions this program (smart metering and time of use pricing) will reduce and how many years the savings can be expected to last when a program runs for many years and is applied to all customers, we assume multiple scenarios on the percentage of energy reduction (e.g., 0.5%, 1.5%, and 3.0% savings). Note that there is the possibility that GHG emissions could increase if this program increases energy consumption at off peak hours, because coal-fired power plants are the dominant source of energy during off-peak hours.

  Summit Blue Consulting (2007) found that customers participating in New Jersey Public Service Enterprise Group's (PSEG's) MyPower Pricing pilot project reduced consumption from 3.3% to 4.3% during the summer time. IBM Global Business Services et al. (2007) found that customers participating in Ontario's Smart Price Pilot reduced energy consumption by 6% during the pilot period, from August 1, 2006 to February 28, 2007 (6 months). Primen (2004) cited past studies that documented energy use reductions of 4% to 15% associated with energy price feedback using an in-home display. However, Primen (2004) is less relevant to RCI-8, because the savings in this study are not associated with time of use pricing that is tied to billing. Furthermore, many cited studies were conducted in other countries, and they do not provide how long the savings lasted.

- *Cost of financing*—8.52% capital recovery factor, consistent with a 6.5% interest rate for utility financing and 20 year asset life.
- *Lifetime of smart metering infrastructure*—20 years.
- *Number of residential and commercial customers*— projected to increase in proportion to the growth rate of electricity consumption.
- *Number of smart meters required per site*—assumed to be equal to the number of total customers.
- *Assumed cost of implementation of inverted-block surcharges*—$0 (placeholder assumption).
- *Avoided electricity cost*—Same assumptions as used for RCI-1.
- *Retail electric rates*—Same assumptions as used for RCI-3.
- *Emission factors*—Same assumptions as used for RCI-1.

Key Uncertainties

There are a number of uncertainties associated with this policy, because there has not been much experience with deployment of smart meters. The level of energy savings from deployment of smart meters is uncertain. Three percent savings is a conservative estimate of savings based on two critical peak pricing pilot projects in New Jersey and Ontario, Canada. Both pilot projects ran only for six months, including summer peak. Annual average savings are likely to be lower because the savings during the other 6 months are likely to be lower. Also, if all customers are required to take time of use service (as is contemplated in this policy, but unlike the conditions in the referenced study), the savings are likely to be significantly lower. The public's reaction to being required to accept smart metering and Time of Use (TOU) rates could be negative. Finally, these estimates are based on customer response for less than a year. No study has estimated how customers would respond to price signals from time of use or critical peak pricing for long periods of time (e.g., 10 to 20 years).

Technological progress in this field is very fast and cost-effectiveness (benefit-cost ratio) of different metering technologies is uncertain. Thus stakeholders, utilities, and the public utility commission need to be careful about the choice of technology.

TOU rates tend to encourage consumers to shift electricity usage to off-peak times. A policy that moves consumption from peak to off-peak times may or may not decrease GHG emissions, depending on whether the generation avoided during times of reduced consumption has lower emissions than the generation that is dispatched when consumption is increased.

Other uncertainties include actions the PSC and the utilities may take in the future.

Additional Benefits and Costs

- Aligning price signals with demand to increase awareness of costs of consumption.
- Savings to consumers and business on energy bills.
- Reduced peak demand and reduced capacity requirements.

- Other electricity system benefits: reduced capital and operating costs, improved utilization and performance of electricity system.
- Reducing energy price increases and volatility.

Feasibility Issues

Legislation may be required for implementation of this policy.

Procurement of wholesale electricity supply may be complicated by the shifts in consumption accompanying the implementation of three-tiered surcharges and TOU rates, especially in the beginning of the program when data are limited. Bidders in the annual Standard Offer Service (SOS) procurement may want information about which meters will be replaced, when, and how consumption is likely to change as a result of the new rate schedules. Administrative costs of providing these data to bidders could be burdensome.

The policy should apply to all customers in the rate class, to avoid switching.

Status of Group Approval

Approved.

Level of Group Support

Unanimous.

Barriers to Consensus

Not applicable.

RCI-9. GHG or Carbon Tax

Transferred to ES TWG.

RCI-10. Energy Efficiency Resource Standard

Policy Description

An EERS is a market-based mechanism to require more efficient use of electricity and natural gas. State public utility commissions or other regulatory bodies set electric and/or gas energy savings targets for utilities. All EERS include end-use energy savings improvements; in some cases, distribution system efficiency improvements and combined heat and power (CHP) systems and other high-efficiency distributed generation systems are included as well.

Policy Design

Goals: Together with RCI-2, require the utilities to achieve energy savings equal to 15% of per capita demand by 2015.

For RCI-10, develop mandatory utility electricity reduction targets of 0.5% of demand in 2009, 1.0% in 2010, 1.5% in 2011–2013, and 2% in 2014–2015.

For RCI-10, develop mandatory utility natural gas reduction targets of 0.5% of demand in 2009, 1.0% in 2010, 1.5% in 2011–2013, and 2% in 2014–2015. The targets apply to natural gas to be used for energy purposes only; natural gas for use as feedstock is excluded.

Timing: As above.

Parties Involved: All load-serving electricity and natural gas entities.

Implementation Mechanisms

Utilities submit plans for efficiency programs to the PSC for approval. The plan must include a diverse portfolio of programs, including home energy assessments, energy efficiency rebates, commercial and industrial programs, training for contractors and facility managers, and demand response programs. The plan should evaluate programs in terms of cost-effectiveness, ability to capture opportunities for energy efficiency that would otherwise be lost, and fair distribution of programs geographically, relative to the source of the funds, and within sectors.

After the plan is approved, utilities issue requests for proposals (RFPs) for each type of energy service. Energy service companies of all shapes and sizes would be encouraged to submit bids and do the work.

Related Policies/Programs in Place

The Empower Maryland goal, set by Governor O'Malley in July 2007, established a statewide goal of reducing per capita electricity consumption and peak demand by 15% by 2015. Modeled on the governor's goal, SB 205/HB 374 requires electric utilities to submit plans to reduce per capita electricity consumption by 10% by 2015.

The Maryland Energy Efficiency Standards Act of 2007 requires the MEA to adopt regulations establishing minimum efficiency standards for a number of consumer products.

RGGI auction proceeds may be dedicated to Energy efficiency. HB 0368/SB 268 established the Maryland Strategic Energy Investment Program and Fund, to decrease energy demand and increase clean energy supply utilizing proceeds from the sale of RGGI allowances. This legislation has not been reflected in the analysis that follows.

The Energy Independence and Security Act of 2007 has three titles particularly relevant to RCI-10: Title III (Appliance and Lighting Efficiency), Title IV (Energy Savings in Building and Industry), and Title V (Energy Savings in Government and Public Institutions).

Type(s) of GHG Reductions

Reduction in GHG emissions (largely CO_2) from avoided electricity production or on-site fuel combustion.

Estimated GHG Reductions and Net Costs or Cost Savings

Table F-25 presents the estimated GHG reductions and net costs or costs savings from implementing RCI-10.

Table F-25. Estimated GHG reductions and net costs of or cost savings from RCI-10

	GHG Reductions ($MMtCO_2e$)			Gross Costs (Million $)	Gross Benefits (Million $)	Net Present Value 2008–2020 (Million $)	Cost-Effective-ness ($/tCO_2e$)
	2012	2020	Total 2008–2020				
RCI–10 Total	**2.9**	**11.9**	**71.0**	**$1,726**	**–$5,396**	**–$3,670**	**–$52**
Electricity demand-side management	2.4	10.3	61.1	$1,426	–$4,404	–$2,978	–$49
Natural gas demand-side management	0.4	1.6	9.9	$300	–$991	–$691	–$70

GHG = greenhouse gas; $MMtCO_2e$ = million metric tons of carbon dioxide equivalent; $/$tCO_2e$ = dollars per metric ton of carbon dioxide equivalent; RCI = Residential, Commercial, and Industrial.

Data Sources:

- *General:* MEA modeling completed by Exeter (electric only, not natural gas).
- *Energy efficiency potential study*: See RCI-2.
- *Cost of energy efficiency measures in Maryland:* See RCI-2.
- *Experience in other states on cost of energy efficiency:* See RCI-2.
- *Cost of saved natural gas*: See RCI-2.
- Avoided cost of fuels: See RCI-2.

Quantification Methods:

- Estimate energy reduction based on the recommended energy reduction targets for electricity and natural gas consumption,
- Estimate the total cost of electricity and natural gas savings, and
- Estimate the GHG emissions reduction through the electric energy efficiency measures.

Key Assumptions:

- *Discount rate:* See RCI-1.
- *Cost of financing:* 0% interest rate (DSM costs are incurred as the Systems Benefits Charge (SBC) is collected).
- *Avoided cost of electricity and fuels:* See RCI-1.
- *Target electricity and natural gas efficiency savings*: Through 2015, the target draws on the stated policy goal. After 2015, 1.6% per year for electricity efficiency and 1.2% per year for natural gas efficiency is assumed, based on a number of DSM potential studies and experience by leading electric and natural gas utilities. Table F-26 presents the electricity and natural gas efficiency savings targets for RCI-10.

Table F-26. Electricity and natural gas efficiency savings trajectory for RCI-10

Year	Electricity Target	Natural Gas Target
2008	0%	0%
2009	0.5%	0.5%
2010	1.0%	1.0%
2011	1.2%	1.2%
2012	1.3%	1.3%
2013	1.5%	1.5%
2014	1.8%	1.6%
2015	2.0%	1.6%
2016	1.6%	1.2%
2017	1.6%	1.2%
2018	1.6%	1.2%
2019	1.6%	1.2%
2020	1.6%	1.2%

- *Cost of electric efficiency measures*—Same assumptions as used for RCI-2.
- *Cost of saved natural gas*—Same assumptions as used for RCI-2.
- *Efficiency measure lifetime*—Same assumptions as used for RCI-2.
- *Displaced emissions*—Same assumptions as used for RCI-1.

Key Uncertainties

The source of funding to implement the aggressive DSM program envisioned here is uncertain.

Consumer response to this program is also uncertain.

Additional Benefits and Costs

- Indoor comfort and air quality improvements, with related improvements in health and productivity.

- Savings to consumers and business on energy bills. Benefits to the low income by reducing utility costs.
- Electricity system benefits: reduced peak demand, reduced capital and operating costs, improved utilization and performance of electricity system.
- Reduced the risk of power shortages.
- Reduced pollutants from emissions, improved health from fewer pollutants and particulates and reduced water use for cooling.
- Green-collar employment expansion and economic development.
- Reducing dependence on imported fuel sources.
- Reducing energy price increases and volatility.

Feasibility Issues

It may be difficult to achieve the aggressive energy savings goals set by this policy.

Status of Group Approval

Approved.

Level of Group Support

Unanimous.

Barriers to Consensus

Not applicable.

RCI-11. Promotion and Incentives for Energy Efficient Lighting

Policy Description

This policy option involves phasing out the sale or use of energy-inefficient incandescent light bulbs in the state. California has announced its plan to phase out the use of incandescent light bulbs by 2018, Nevada adopted a lighting efficiency standard for light bulbs sold beginning in 2012, and a number of other states are considering similar policies, including Connecticut, Rhode Island, and New Jersey. Australia and Ontario, Canada, have announced similar bans.

Incandescent bulbs waste roughly 95% of the electricity they consume—emitting heat rather than light. In contrast, efficient light bulbs emit more light (lumens) while consuming less electricity (watts). The typical incandescent bulb produces 14 lumens per watt, whereas a compact fluorescent bulb produces 63 lumens per watt. Compact fluorescent light (CFL) bulbs have the additional advantage of lasting up to ten times as long without burning out. With current prototypes boasting even higher efficiencies than CFLs, light-emitting diodes (LEDs) show promise for widespread use in a variety of different applications, including general service lighting, if production costs can be lowered.

Policy Design

Goals: Implement aggressive campaigning and incentives encouraging residential customers to purchase screw-in compact fluorescent light bulbs or other high-efficiency lighting as needed to replace their screw-in incandescent light bulbs. Screw-in compact fluorescent bulbs will make up 95% of residential light bulb sales by 2014.

Timing: As above.

Parties Involved: Residential customers.

Implementation Mechanisms

Voluntary measures would be encouraged through public awareness campaigns.

The state should consider whether mercury from disposal of compact fluorescent bulbs may present a concern to human health or the environment. MDE has a webpage with instructions on proper disposal of CFLs (http://www.mde.state.md.us/Programs/LandPrograms/Solid_Waste/cfl_mercury.asp); however, a more comprehensive, widely accessible recycling program for residential and commercial bulbs may be appropriate.

Related Policies/Programs in Place

- Energy Independence and Security Act of 2007: This federal law establishes new minimum efficiency standards for common light bulbs, requiring them to use about 20%–30% less energy than present incandescent bulbs by 2012–2014 (phasing in over several years) and requiring a U.S. Department of Energy (DOE) rulemaking to set standards that will reduce energy use to no more than about 65% of current lamp use by 2020.

- Campaigns by utilities to promote use of CFLs and other energy efficient lighting:
  - Allegheny Maryland's Compact Fluorescent Light Energy Efficiency Program (http://www.alleghenypower.com/EngConserv/MdCFLProgram.asp),
  - BGE's Change a Light campaign (http://bgesmartenergy.com/changealight.html) and CFL discounts (http://bgesmartenergy.com/lighting.html),
  - DPL Maryland's CFL campaign (http://www.delmarva.com/home/education/cfl/), and
  - Pepco Maryland's CFL campaign (http://www.pepco.com/home/education/cfl/).
- The EmPOWER Maryland goal, set by Governor O'Malley in July 2007, established a statewide goal of reducing per capita electricity consumption and peak demand by 15% by 2015. Modeled on the governor's goal, SB 205/HB 374 requires electric utilities to submit plans to reduce per capita electricity consumption by 10% by 2015.
- RGGI auction proceeds may be dedicated to Energy efficiency. HB 0368/SB 268 established the Maryland Strategic Energy Investment Program and Fund, to decrease energy demand and increase clean energy supply utilizing proceeds from the sale of RGGI allowances. This legislation has not been reflected in the analysis that follows.

Type(s) of GHG Reductions

Reduction in GHG emissions (largely CO_2) from avoided electricity production or on-site fuel combustion.

Estimated GHG Reductions and Net Costs or Cost Savings

Table F-27 presents the estimated GHG reductions and net costs or costs savings from implementing RCI-11.

Table F-27. Estimated GHG reductions and net costs of or cost savings from RCI-11

	GHG Reductions ($MMtCO_2e$)			Gross Costs (Million $)	Gross Benefits (Million $)	Net Present Value 2008–2020 (Million $)	Cost-Effective-ness ($/tCO_2e$)
	2012	2020	Total 2008–2020				
RCI–11	0.1	1.1	7.7	$153	–$516	–$362	–$47

GHG = greenhouse gas; $MMtCO_2e$ = million metric tons of carbon dioxide equivalent; $/$tCO_2e$ = dollars per metric ton of carbon dioxide equivalent.

Data Sources:

- U.S. Department of Energy. U.S. Lighting Market Characterization, Volume I: National Lighting Inventory and Energy Consumption Estimate. Prepared by Navigant Consulting, Washington, DC: U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, Building Technologies Program, September 2002.
- One Billion Bulbs. Summary Statistics for Maryland. http://www.onebillionbulbs.com/Stats/State/MD (accessed December 11, 2007).

- 2004–2005 Database for Energy Efficiency Resources Update Study. California Public Utilities Commission and California Energy Commission, Prepared by Itron, Inc., December 2005.
- California Lamp Report 2003. Prepared for: Southern California Edison, Prepared by: Itron, Inc., July 15, 2004.
- Report to Baltimore Gas and Electric: Demand-Side Management Program Measure Impact and Cost. Submitted to: Honeywell Utility Solutions, Prepared by: Summit Blue Consulting, LLC, November 12, 2007.
- Residential Energy Efficiency Program Design Recommendations. Submitted to Baltimore Gas and Electric, Prepared by: American Council for an Energy Efficient Economy (ACEEE), October 2006.
- Forefront Economics, Inc., H. Gil Peach & Associates LLC, and PA Consulting Group. “Duke Energy Carolinas DSM Action Plan: South Carolina Draft Report.” July 24, 2007.
- U.S. Congress. House. *Energy Independence and Security Act of 2007*. H.R.6. 110th Cong., 1st sess.

Quantification Methods:

- Estimate the lumen/watt output of all light bulbs currently sold in the United States.
- Estimate the ramp in rate necessary for achieving the Maryland-specific goal and the minimum targets under the federal 2007 Energy Bill.
- Estimate the current and projected number of screw-in light bulbs (all types) sold in Maryland.
- Estimate the current and projected number of screw-in compact fluorescent light bulbs sold in Maryland.
- Estimate the amount of energy saved by meeting the Maryland-specific goals (excluding the amount of energy saved by meeting the 2007 federal energy bill targets).
- Estimate the total cost by multiplying the number of bulbs sold under the Maryland-specific goal by the incremental cost of each compact fluorescent light bulb.

Key Assumptions:

- The energy savings, GHG emissions reductions, benefits, and costs apply only to new light bulbs sold in Maryland after 2008.
- An average compact fluorescent light bulb outputs 63 lumens/watt, while an average incandescent light bulb outputs 14 lumens/watt. (LEDs were not modeled in this analysis.)
- Analysis applies only to the residential sector and medium screw-based light bulbs.
- Annual energy savings of installing a compact fluorescent instead of an incandescent light bulb: 51 kWh/year.
- Average lifetime of a compact fluorescent light bulb: 10,000 hours.
- Average number of hours used per day: 4.

- Average incremental cost of a compact fluorescent over an incandescent light bulb: $6.33/bulb.
- Number of residential screw-based lamps (all types) sold nationally: 1,369,310,000 in 2003
- Market penetration of ENERGY STAR residential light bulbs in screw-in light bulbs sold nationally.
- The purchases of compact fluorescent light bulbs by residential customers ramp up linearly from the current market penetration to 95% of light bulbs sold by 2014 and then holds steady at 95% through 2020.
- Market share of medium screw-based halogen bulbs stays constant.
- Maryland residential customers as a percentage of total U.S. customers: 1.8%.

Key Uncertainties

It should be investigated whether additional efforts into collection and disposal of compact fluorescent bulbs, beyond current recycling efforts and information dissemination,[2] is needed to avoid mercury contamination.

It is unclear how manufacturers will respond to the 2007 federal energy bill, which requires common light bulbs to use 25%–30% less energy by 2012–2014 and a minimum efficiency of 45 lumens/watt for all bulbs sold by 2020. Retailers are assumed to linearly ramp up the efficiency of their light bulbs sold to meet the 2007 Energy Bill targets, beginning in 2009. This assumption gives the most conservative estimation of Maryland-specific energy savings.

This analysis assumes that customers would bear all incremental costs of replacing an incandescent light bulb with a compact fluorescent light bulb. However, direct incentives will probably be required to achieve the voluntary target stated in this policy. For example, in a November 2007 report to BGE from Summit Blue Consulting, the recommended incentive was $1.50 per screw-in compact fluorescent bulb (shown in Table F-28).

Table F-28. Recommended incentives per compact fluorescent bulb for the BGE service territory

Demand/Energy Savings						Incentive Calculations				Customer Cost/Savings			
								PV Program				Payback	
Fixture Type	Incand. Fixture Watts	CFL Fixture Watts	Non-Coincid. Demand Savings (kW)	On-pk Energy Savings (kWh)	Off-pk Energy Savings (kWh)	PV Benefit ($)	Recom-mended Incentive ($)	Cost ($)	NPV ($)	Incr. Cost ($)	Cost Savings ($)	Without incr. (years)	With incr. (years)
Screw-in	35	9	0.026	18	8	$18	$1.50	$6	$12	$5.03	$3	1.4	1
	75	20	0.055	39	16	$39	$1.50	$6	$33	$5	$7	0.7	0.5
	150	41	0.109	77	32	$76	$1.50	$8	$68	$7.21	$15	0.5	0.4
Weighted average			**0.072**	**51**	**21**	**$50**	**$1.50**	**$7**	**$43**	**$5.89**	**$10**	**0.74**	**0.54**

Source: Summit Blue Consulting 2007

[2] See MDE, Statement on Compact Fluorescent Light Bulbs and Mercury, available at: http://www.mde.state.md.us/Programs/LandPrograms/Solid_Waste/cfl_mercury.asp. Accessed April 8, 2008.

PV = photovoltaics; incand. = incandescent; CFL = compact fluorescent lamps; coincid. = coincidental; kW = kilowatt; on-pk = on peak; off-pk = off peak; NPV = net present value; incr. = increase.

Existing penetration of CFLs into the residential sector may be higher. A recent national study estimates penetration at 20%. However, a change to this assumption does not materially change the results of the policy analysis.

Additional Benefits and Costs

- Exposure to fluorescent bulbs producing light in the blue part of the spectrum suppresses the body's production of melatonin more than conventional incandescent bulbs. Melatonin helps to prevent tumor formation, which suggests that there may be a link between blue-light emitting CFLs and cancer. (Weiss, Rick. "Lights at Night Are Linked to Breast Cancer" Washington Post, Feb 20 2008. http://www.washingtonpost.com/wp-dyn/content/article/2008/02/19/AR2008021902398_pf.html)
- Savings to consumers and business on energy bills. Benefits to the low income by reducing utility costs.
- Electricity system benefits: reduced peak demand, reduced capital and operating costs, improved utilization and performance of electricity system.
- Reducing pollutants from emissions, improved health from fewer pollutants and particulates and reduced water use for cooling.
- Reducing dependence on imported fuel sources.
- Reducing energy price increases and volatility.
- Additional costs associated with the collection and disposal of compact fluorescent bulbs.

Feasibility Issues

95% target is aggressive.

Status of Group Approval

Approved.

Level of Group Support

Unanimous.

Barriers to Consensus

Not applicable.

Maryland Climate Action Plan

Appendix D-4

Transportation & Land Use

Transportation and Land Use

Introduction

This document outlines policies, tools, and programs needed to ensure that transportation and land development contribute to achieving Maryland's greenhouse gas (GHG) emissions reduction goals.

The GHG reductions estimated for the proposed priority policy options are listed in the table below. The policies are not listed in the order discussed in the text that follow the table, but rather are grouped to reflect how the policy options will affect emissions. Specifically, the factors that determine GHG emissions from the transportation sector, and addressed in the policy options, can be categorized as follows:

- Transportation carbon emissions = miles driven × carbon per mile.
- Carbon per mile = vehicle emissions per unit × carbon per unit of fuel.

Thus, reducing GHG emissions requires reducing

- The number of miles driven,
- The carbon per unit of fuel (cleaner fuels), and
- The carbon per mile and per hour emitted by vehicles (improved vehicle efficiency).

The policy options are grouped as follows: those that affect the number of miles driven comprise Transportation and Land Use (TLU) Area 1, those related to cleaner fuels comprise TLU Area 2, and those related to improved vehicle efficiencies comprise TLU Area 3.

Note that while specific data and assumptions are useful for quantification purposes, they should be seen as neither fully constraining, nor as fully defining of the measures. The specific emission reduction calculations outlined in the draft policy document often imply more reliability than currently exists. These are intended as a first-order illustration of the potential for these measures. These strategies can and should be refined, and more thoroughly analyzed in the near future.

Summary List of Draft Priority Policy Options for Analysis [AU: Gloria, check this table title for match with others.]

Option No.	Policy Option	GHG Reductions ($MMtCO_2e$)			Net Present Value 2008–2020 (Million $)	Cost-Effectiveness ($/tCO_2e$)	Level of Support
		2012	**2020**	**Total 2008–2020**			
TLU Area 1: Reduce VMT's contributions							
TLU-2	Integrated Planning for Land Use and Location Efficiency	1.1	3.6	23.7	*Large net savings*		Unanimous
TLU-3	Transit	1.1	2.2	17.5	*Large net savings*		Unanimous
TLU-5	Intercity Travel: Aviation, Rail, Bus, and Freight	0.2	0.3	1.9	*Net savings*		Unanimous
TLU-6	Pay-As-You-Drive (PAYD) Insurance	1.0	3.4	23.0	*Net savings*		Unanimous
TLU-8	Bike/Pedestrian Infrastructure	*Included in TLU-3 quantification*					Unanimous
TLU-9	Incentives, Pricing, and Resource Measures	2.6	3.7	32.8	–$1	–$1	Unanimous
TLU-11	Evaluate the Greenhouse Gas (GHG) Emissions Impacts of Major Projects	*N/A*					Unanimous
Total of Individual Options		6.0	13.2	98.9			
TLU Area 2: Reduce carbon per unit of fuel							
TLU-4	Low Greenhouse Gas Fuel Standard (LGFS)						Not approved
TLU Area 3: Reduce carbon per mile and per hour							
TLU-10	Transportation Technologies	2.70	2.83	14.7	$4,091	($200)–$1,500	Unanimous
	Sector Total Before Adjusting for Overlaps, Using ONLY the Area Totals	**8.7**	**16.03**	**113.6**			
	Reductions From Recent Actions	**0.18**	**0.20**	**1.67**			
	Sector Total Plus Recent Actions	**8.88**	**16.23**	**115.27**			

GHG = greenhouse gas; $MMtCO_2e$ = million metric tons of carbon dioxide equivalent; $/tCO_2e$ = dollars per ton of carbon dioxide equivalent; VMT = vehicle miles traveled; N/A = not applicable.

As the TLU Technical Working Group (TWG) worked to set appropriate goals for each of the TLU Area 1 policy options, the TWG also sought guidance from the level of needed reductions.

Maryland set statewide goals for reducing GHG emissions, and while there is no mandate that the emission reductions for each sector be commensurate with the current and projected contribution of the sector to emissions, it is a benchmark against which to compare the reductions estimated for the policy option goals.

The statewide goals for GHG emissions reductions in Maryland are

- 10% below 2006 GHG emissions levels by 2012,
- 15% below 2006 GHG emissions levels by 2015, and
- 25%–50% below 2006 GHG emissions levels by 2020.

If each sector were expected to participate in the reduction efforts in proportion to their contribution, then in 2020 a 25%–50% reduction below 2005 GHG emissions levels would also be expected from the transportation sector.

Table H-1 shows historical, current (2005, the last year for which date were available for this report) and projected contributions of the transportation sector to Maryland GHG emissions, and emissions required to contribute proportionately to the 2015 and 2020 goals:

Table H-1. Maryland GHG emissions

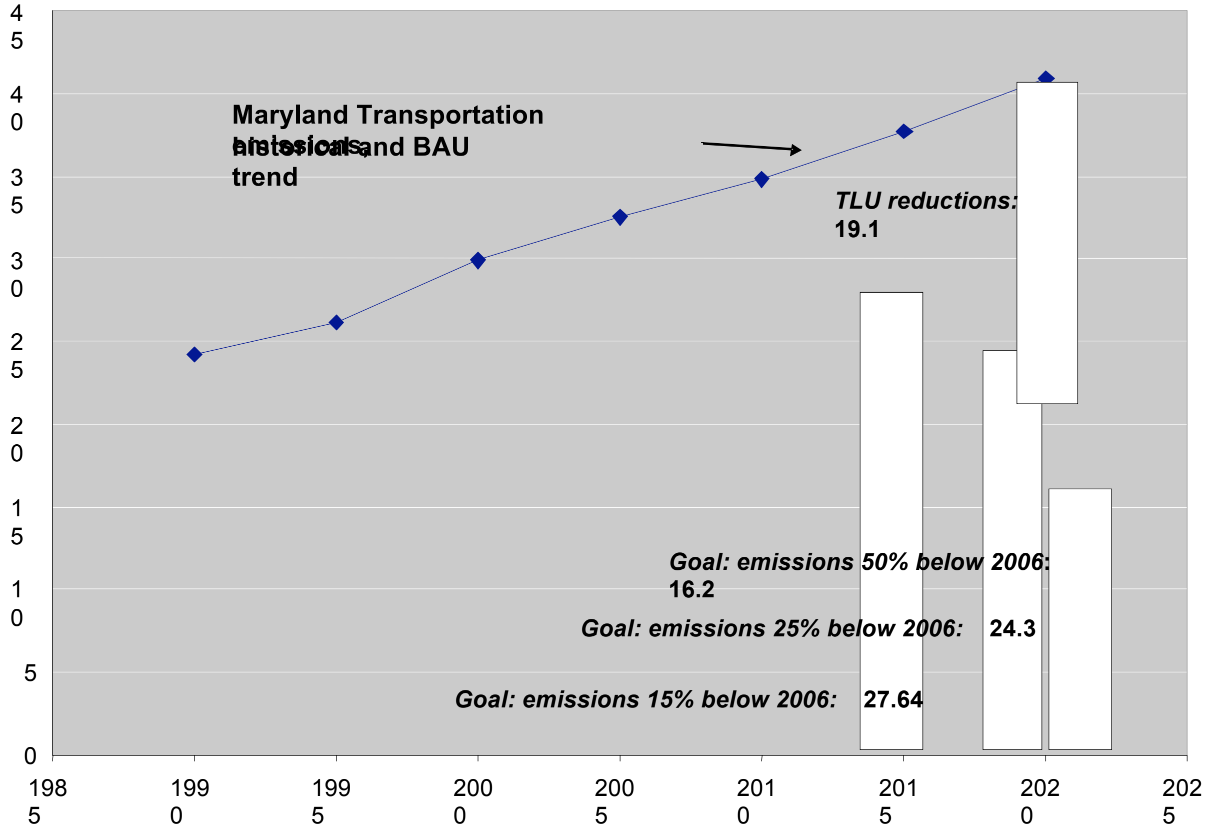
	$MMtCO_2e$						
Source	**1990**	**1995**	**2000**	**2005**	**2010**	**2015**	**2020**
On-road Gasoline	17.91	19.67	21.61	23.94	25.29	26.97	28.78
On-road Diesel	2.91	3.42	5.09	5.89	6.83	7.91	9.18
Jet Fuel/Aviation Gas	1.49	1.41	1.68	1.31	1.32	1.37	1.42
Boats and Ships—Ports/Inshore	1.16	0.90	0.90	0.87	0.81	0.87	0.93
Boats and Ships—Offshore	0.21	0.35	0.39	0.31	0.33	0.35	0.37
Rail	0.39	0.27	0.05	0.06	0.06	0.06	0.06
Other	0.14	0.14	0.16	0.14	0.16	0.18	0.19
Total emissions	**24.20**	**26.16**	**29.90**	**32.52**	**34.81**	**37.71**	**40.93**

GHG = greenhouse gas; $MMtCO_2e$ = million metric tons of carbon dioxide equivalent.

Goal (if proportionate) =	2006 *
–15%, so 32.52 – 15% =	total emissions of 27.64
–25%, so 32.52 – 25% =	total emissions of 24.39
–50%, so 32.52 – 50% =	total emissions of 16.26
All TLU Area reductions together would reduce Maryland emissions by	–19.15
Leaving total remaining emissions of 40.93 – 19.15 =	21.78
21.78/40.93 = 53%; so all TLU options together produce a reduction of	~47% from 2020 BAU

As demonstrated by Table H-1 and Figure H-1, the TLU policy options, if implemented aggressively, produce emissions reductions within the range of 25% and 50% reductions from 2006 emissions levels.

Figure H-1. GHG projections and goals in 2020



BAU = business as usual; TLU = Transportation and Land Use.

Reductions from Recent Actions

This quantification is based on actions taken by the Maryland Department of Transportation (MDOT) in the last few years, and include intelligent transportation systems (ITS) (e.g., Coordinated Highways Action Response Team [CHART]), incentives for ridesharing and telecommunications programs, Guaranteed Ride Home (GRH) for transit users, low-carbon fuels (bio-diesel) purchases by state fleets, and traffic signal synchronization. These actions were found to decrease transportation emissions by 0.08 million metric tons of carbon dioxide equivalent ($MMtCO_2e$) in 2012, and 0.11 $MMtCO_2e$ in 2020. These emissions reduction quantifications were based on MDOT calculations submitted to the Center for Climate Strategies (CCS) on April 15, 2008, or on previous analyses done for the state (ongoing Transportation Emission Reduction Strategies, MDOT).

Transportation and Land Use
Policy Descriptions

TLU Area 1: Reduce the contribution of VMT to GHG emissions

This suite of policies will reduce the state's GHG emissions by reducing the growth in vehicle miles traveled (VMT). The TLU TWG highly recommends these policy options be implemented as a group. All options in this area save money, and all target policy areas that require change in order to meaningfully reduce GHGs from the TLU sector.

Within this group of options, the important variable is the strength of implementation. These policies have substantial power to reduce GHGs. The quantification in the following table, and in each of the policy option descriptions, is based on an aggressive implementation of each policy option. This aggressive implementation of TLU policies would help contribute to attaining the high end of Maryland's goal of reducing GHG emissions by 25%–50% by 2020. Less aggressive implementation would reduce VMT by 20%, contributing to meeting the lower end of the state's 25%–50% reduction goal. Put another way, the TWG's recommendation to the Mitigation Working Group (MWG) is: *if* the state desires to vary the aggressiveness of the final package of measures, *then* it should do so by varying the aggressiveness of the package and of the policies within it. The TWG recommended against varying the aggressiveness of the package by adding or deleting individual policies.

For example, TLU-6, Pay-As-You-Drive Insurance (PAYD), can have a range of emissions reductions, depending on how it is implemented. If it covers only "miles driven," it will reduce the number of miles driven, and produce smaller impacts. If (as recommended) it covers also driving style, it will produce a more efficient method of driving (for example, less speeding), and thus reduce GHG emissions from improved efficiency. The technology for the broader implementation has been successfully deployed in the commercial sector. The TWG recommends that Maryland aggressively work with its insurance commission and with the insurance industry to implement the broadest deployment of PAYD possible, in terms of drivers covered, and of covered mileage and driving styles. But the TWG also recognizes the likelihood of such aggressive implementation is smaller than that of a modest implementation.

To summarize, the quantification shown is for aggressive implementation of all policy options. At a less aggressive level of implementation, expected GHG reductions would tend toward one-half of the reductions shown.

Table H-2. VMT reduction options considered in TLU Area 1

Option No.	Policy Option	GHG Reductions ($MMtCO_2e$)		
		2012	2020	Total 2008–2020
TLU Area 1				
TLU-2	Integrated Planning for Land Use and Location Efficiency	1.1	3.6	23.7
TLU-3	Transit	1.1	2.2	17.5
TLU-5	Intercity Travel: Aviation, Rail, Bus, and Freight	0.2	0.3	1.9
TLU-6	Pay-As-You-Drive (PAYD) Insurance	1.0	3.4	23.0
TLU-8	Bike/Pedestrian Infrastructure	*Included in TLU-3 quantification*		
TLU-9	Incentives, Pricing, and Resource Measures	2.6	3.7	32.8
TLU-11	Evaluate the Greenhouse Gas (GHG) Emissions Impacts of Major Projects	*N/A*	*N/A*	*N/A*
Total of individual options		**6.0**	**13.2**	**98.9**

GHG = greenhouse gas; $MMtCO_2e$ = million metric tons of carbon dioxide equivalent; TLU = Transportation and Land Use; PAYD = Pay-As-You-Drive; N/A = not applicable.

TLU-2. Integrated Planning for Land Use and Location Efficiency

Policy Description

Implement land-use planning and development strategies that reduce the number of VMT and corresponding GHG emissions. Strategies include adopting statewide growth-management plans and planning process reforms to encourage more compact development, transit-oriented development (TOD), transportation management system (TMS) and pricing, and other tools that encourage people to drive fewer miles, while ensuring a competitive economy and affordable housing opportunities for Maryland residents.

Policy Design

Goals:

To return statewide VMT to 2000 per capita levels by 2020 and ensure continuing reductions in per capita VMT (excluding vehicles over 10,000 pounds engaged in commercial freight activity) of 30% by 2035, and 50% by 2050, from a 2020 per capita baseline, by implementing policies to maximize growth management and incentivize GHG emissions reductions in the following areas:

- Land-use planning and regulation policies;
- Development and housing policies that shape public and private investment; and
- Integrated transportation policies, investments, management, and pricing systems.

Timing: Governor and appropriate Cabinet Secretaries should initiate planning and administrative activities in 2008 to shape transportation plans and policies to support the goal in 2008 and beyond, and prepare additional legislation for 2009 the legislative session.

Parties Involved: Maryland Department of Planning (MDP)—Office of Smart Growth (OSG), MDOT, Maryland Department of Housing and Community Development (DHCD), Maryland Department of the Environment (MDE), Maryland local governments, real estate development industry, economic development interests, environmental and community interest groups.

Other:

The 2000 benchmark in Maryland is 9,496 miles traveled per capita based on a 2000 population of 5.3 million, and 2000 VMT of 50,296 million miles.

The comparable statistics for 2005 are 10,200 miles per capita based on a 2005 population of 5.56 million, and 2005 VMT of 56,725 million miles.

2020 projections estimate VMT per capita in Maryland in that year of 11,519.

Therefore, the needed VMT *per capita* reduction in Maryland from 2020 business-as-usual (BAU) estimates to reach 2000 levels is 18%. This would result in a total VMT of 60,643 million given a 2020 forecast population of 6,386,225, and would be an increase of 6.9% from total 2005 VMT.

Additionally, the TLU supports a goal of a 35% reduction in per capita VMT (excluding vehicles over 10,000 pounds engaged in commercial freight activity) by 2035 and a 50% reduction by 2050, consistent with the goals recently established as benchmarks in Washington State House Bill 2815, which was signed into law in 2008.[1] These goals should be used in refinement of state, regional, and local long-range TLU plans. Setting such longer-term goals is especially important because federal law requires the periodic updating of state and metropolitan transportation plans with at least a 20-year planning horizon. The degree of timely progress towards these goals should be monitored, evaluated and reported with each plan update.

Implementation Mechanisms

Governor and appropriate Cabinet Secretaries should initiate planning and administrative activities in 2008 to shape transportation plans and policies designed to minimize GHG emissions related to traffic, while supporting sound economic and community development and affordable housing goals in 2008 and beyond.

The Governor should convene a Task Force of key state and local leaders and stakeholders to develop further recommendations for the Governor and Legislature by November 30, 2008 on initiatives and options to reduce traffic growth through better integrated TLU planning and management.

The Governor should work with the Legislature to develop supportive laws to meet these goals.

The Governor should establish an independent state agency to coordinate smart growth activities.

Several strategies and mechanisms should be considered in addressing these three policies outlined under policy design.

- Land-use planning and regulation policies
  - Require climate-friendly compact growth and integrated TLU planning.
    - Adopt a statewide development plan, including a GHG emissions cap for regional TLU plans and programs.
    - Develop GHG budgets and VMT per-capita targets for local, county, regional, and state land-use and infrastructure plans.
    - Develop a mechanism for coordinating with, and comparing local and county land use and infrastructure plans with, the statewide growth-management plan to ensure consistency and compatibility.
    - Develop and ensure funding for appropriate institutional capacity at the state, regional, and local level for planning, data collection, analysis, and performance monitoring to support effective integrated transportation, land use, and environmental planning and system management.
  - Require local comprehensive plans and environmental impact statements, fostering more integrated local TLU plans, policies, and pricing incentives designed to minimize GHG

[1] http://apps.leg.wa.gov/billinfo/summary.aspx?bill=2815

emissions, while supporting sound economic and community development and affordable housing goals.

    - Direct state spending (including sewer and water) to communities that adopt land-use planning and regulation best practices to meet the GHG budget and VMT performance standards set, with competitive grants available for efforts that extend best practices in reducing GHGs related to transportation demand and system management, and bonus funding to communities for demonstrating measurable exemplary progress in meeting these goals.
    - Require and support zoning for smart growth.
    - Enhance open-space protection programs and policies to focus on protection and development of carbon sinks, and concentrate development in existing urbanized areas.

- Development and housing policies that shape public and private investment to foster growth and redevelopment to minimize and incentivize GHG emission reductions, while supporting economic development and affordable housing goals.

    - Create smart location requirements and incentives for developers, business, and homeowners.
    - Support sound development and redevelopment of cities, towns, and villages by creating and expanding appropriate tax incentives and funding programs.
    - Fund the reform of state and local tax, zoning, and building codes and policies to support and incentivize appropriate growth and redevelopment.
    - Develop an indirect source rule that provides for GHG impact fees on new development. Examples of indirect source rules that are available elsewhere in the United States should be reviewed, and a rule appropriate for Maryland should be developed from the examples.

- Transportation policies that are designed to minimize GHG emissions, while supporting sound economic and community development and affordable housing goals.

    - Foster expeditious progress in achieving VMT reduction targets, with timely development of more effective VMT measurement, monitoring, and state and local planning and system management. State transportation funding should be tied to progress in planning and implementing measures that achieve adopted goals. The TWG envisions a state and metropolitan planning organizations (MPO) consultative process to establish rules and requirements, but with establishment and management at the state level.
    - Targets should be set as follows:
        - Set a carbon dioxide (CO_2) cap for the transportation sector (for example, following the model of Clean Air Act "conformity").
        - Set a VMT cap that is a subset of the CO_2 cap. The VMT cap would take into account the effects of other impacts on CO_2 from the transportation sector, including improvements in fuel economy and other impacts from measures developed through this process, and set a VMT goal necessary to meet the CO_2 goal, given all other factors.
        - Develop a statewide plan with targets to reduce annual per capita non-commercial light-duty VMT consistent with the VMT goal.

    - The state should adopt a schedule of statewide per capita VMT reduction targets.
    - Schedule would include goal to reduce annual per capita VMT from a BAU projection for 2020 to 1990 levels.
    - As the per capita VMT reduction plan would be a partnership connecting the state, regional, and local levels, the state should design a plan in consultation with local governments that helps direct state actions and investments, incentives, regulations, and policies to achieve the targets.
  - Apportion responsibilities of that plan to planning organizations, inclusive of local jurisdictions.
    - Local governments must adopt VMT plans consistent with statewide plans.
    - State to develop and provide guidance to the local transportation groups, with a wide range of tools and best practices in order to reach the identified benchmarks.
    - Significant state oversight is anticipated, and much of the attainment in per capita VMT reductions is expected to result from complementary actions considered by the TWG.
  - Prioritize funds to significantly expand and improve transit and paratransit systems, walking, and cycling, giving these clearer priority in the allocation of street space and providing alternatives to single-occupancy vehicular (SOV) travel.
  - Fully consider direct, indirect, secondary, and induced impact costs and cost-effectiveness of strategies that preserve and better manage existing roadways and other transportation system elements before investing in new major transportation capital investments and capacity expansion.
  - Introduce new pricing incentives for roads, parking, transit, and motor vehicle ownership to support these goals.
- Develop appropriate funding incentives, regulations, and policies to ensure that the plans are respected and result in timely progress to achieve goals.
- Develop appropriate public-private cooperation and governance structures to help manage travel at a sub-area and district level, especially Transportation Management Districts (TMD). MDOT should work with local governments to designate TMDs to identify and coordinate strategies to manage motor vehicle travel, with the state providing initial funding for TMD operation and related data analysis, reporting, and stakeholder involvement. TMDs will engage Maryland State Highway Administration (SHA), MDP, Maryland Transportation Authority (MDTA), Maryland Transit Administration (MTA), area transit agencies, MDE, MDP OSG, and affected or interested stakeholders, and will be encouraged to work closely with applicable local, regional, and state agencies and the private sector to achieve their goals.

  TMDs will encourage transit-oriented smart growth, public transportation investment, and smart transportation pricing incentives, advising and commenting on relevant initiatives by local and state agencies. TMDs will design and coordinate initiatives, incentives, and investment proposals to: reduce vehicle miles of travel (VMT) per capita in their area of operation to help meet state goals; increase use of public transportation, ridesharing, walking, and bicycling; and reduce direct and indirect GHG emissions related to transportation and land development. TMDs will retain consultants to design appropriate VMT and mode share monitoring programs and provide independent annual reporting on progress towards their goals, with opportunity for public comment.

Related Policies/Programs in Place

Smart Growth Priority Funding Areas.

Task Force on the Future for Growth and Development.

The proposed policy would build on the model of Clean Air Act conformity, adapting that model to growth in VMT and CO_2. That model takes one piece of a state-level challenge—future growth—and gives it to local jurisdictions closest to the source of the growth. The model uses the locals' structure to respond, while building on incentives and technology adopted by the state.[2]

Type(s) of GHG Reductions

Primarily CO_2

Estimated GHG Reductions and Net Costs or Cost Savings

GHG impacts:

Current reductions assume a return to 2000 per capita VMT in 2020, which is an 18% reduction from BAU 2020 VMT. All else is held constant.[3]

Costs/cost savings:

All else being equal, buildings cost somewhat more to construct in urban areas than in suburban or exurban areas. The preponderance of the evidence, and of the academic review of that evidence, finds that increased private construction costs are more than paid for through initial higher sales prices and higher resale value over time, and through substantial savings in reduced infrastructure costs.

Under a compact, TOD scenario, such as would be produced under this option, the state would save substantial infrastructure costs. A portion of those benefits would come from the transit use that improved land-use patterns would make possible. More compact land use alone would produce net cost savings, as the more compact development pattern by itself would save substantial amounts. A wide variety of literature shows that integrated TLU planning produces net savings on total costs of buildings + land + infrastructure + transportation. Some portions of that total cost may be higher. The preponderance of literature suggests net savings overall.[4] A National Academy of Sciences (NAS) and Transportation Research Board (TRB) review found substantial regional and state-level infrastructure cost savings from more compact development, as shown in Table H-1.

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[2] See, for example, Environmental Defense, "Incorporating Environmental Performance into Transportation Projects," memo to TLU TWG, January 30, 2008.

[3] This is consistent with the target adopted in recently signed Washington State climate change legislation.

[4] Literature reviews include US EPA (2001), "Our Built and Natural Environments: A Technical Review of the Interactions Between Land Use, Transportation, and Environmental Quality," and Burchell, et al. in footnote 5.

Costs of sprawl were estimated based on studies by Burchell and are displayed in Table H-3.

Table H-3. Burchell findings of savings of compact growth versus trend development[5]

Area of Impact	Lexington, Kentucky and Delaware Estuary	Michigan	South Carolina	New Jersey
Public–private capital and operating costs				
Infrastructure roads (local)	14.8%–19.7%	12.4%	12%	26%
Utilities (water/sewer)	6.7%–8.2%	13.7%	13%	8%
Housing costs	2.5%–8.4%	6.8%	7%	6%
Cost-revenue impacts	6.9%	3.5%	5%	2%
Land/natural habitat preservation				
Developable land	20.5%–24.2%	15.5%	15%	6%
Agricultural land	18%–29%	17.4%	18%	39%
Frail land	20%–27%	20.9%	22%	17%

Data Sources: CCS inventory and forecast.

Quantification Methods: Top-down.

Key Assumptions: None cited.

Key Uncertainties

There is substantial discussion in the TWG about whether land use and location efficiency can produce the gains at the high end of the quantified range.

Additional Benefits and Costs

None cited.

Feasibility Issues

None cited.

Status of Group Approval

Approved.

Level of Group Support

Unanimous.

Barriers to Consensus

None.

[5] R. Burchell et al. 1998. The costs of sprawl—revisited. TRB/National Research Council (NRC)/National Academies Press (NAP). TCRP Report 39.

TLU-3. Transit

Policy Description

Shift passenger transportation mode choice to increase transit ridership and carpooling. This strategy will reduce GHG emissions by reducing VMT (fewer vehicle trips). Ensure that transportation is integrated with and appropriately serves land-use development plans (developed under TLU-02).

This option supports and enables TLU-09 (Incentives, Pricing, and Resource Measures) in a variety of ways. For one, recent findings in a road charging experiment demonstrate that responses to roadway tolling are more pronounced in areas where transit to workplaces is an option for participants[6]. Additionally, the transportation pricing and commuter choice policies recommended under TLU-09 cannot be effectively advanced if the state transit infrastructure cannot meet the demands and expectations of the SOV commuters for higher quality, convenient, and attractive public transportation, walking, and cycling options. As such this option should be bundled with TLU-09, as the potential to achieve forecast GHG reductions from pricing is limited without the implementation of TLU-3 transit (as well as TLU-8 pedestrian and cycling) improvements. If not bundled, the GHG reductions, costs and benefits from the policy options would need to be revised.

Policy Design

Goals:

- To double transit ridership statewide by 2020 from a 2006 baseline;
- Improve transit service and expand transit infrastructure (rail, bus);
- Focus new development and growth on transit-served corridors;
- Expand transit marketing and promotion; and
- Expand low GHG options.

Timing: To begin immediately.

Parties Involved: MTA

Implementation Mechanisms

The following strategies should be implemented.

Improve transit service and expand transit infrastructure (rail, bus)

- **Planning:**

[6] M. Kitchen. 2008 (Mar.). PowerPoint presentation on lessons from road charging experiments/traffic choices study: Central Puget Sound region, Washington/findings from a road pricing experiment. Prepared for the Puget Sound Region Council (PSRC).

  - Coordinate rideshare, transit, park and ride, bike/pedestrian and interstate transportation planning and investment at the state, regional and municipal levels
  - Prioritize regional routes for expansion, emphasizing cost-effective Bus Rapid Transit (BRT) to maximize service expansion.
- **Capital/Infrastructure:**
  - Improve walking, bicycling, and park-and-ride transit access with a focus on cost-effectiveness in expanding ridership and minimizing GHG emissions. Towards this end, ensure safe and attractive conditions for walking within ¼ mile of transit stops; ensure secure parking for bicycles at transit stops with safe and attractive conditions for cycling within ½ mile of transit stops, and improve Park and Ride Lots by expanding construction of well-lighted and police patrolled parking.
  - Designate and develop more effective multimodal hubs (terminals and shelters), especially at centers where TOD is being encouraged
  - Invest in technology improvements including real-time public transportation customer information, real-time ride-matching and private paratransit services, and public transportation priority treatments in traffic operations
  - Expand operations and maintenance facilities (transit bases) as needed to support effective system development.
- Operating:
  - Improve public transport access within and between development centers
  - Provide new services for developing areas in coordination with the permitting of new developments
  - Increase resources available to elderly and disabled populations (paratransit),
  - Provide public transportation and paratransit assistance to rural areas, and
  - Coordinate schedules of transit services
  - Improve transit times using TMS, signal prioritization, managed lanes, and other priority treatments.

Focus new development and growth on transit-served corridors

Expand transit marketing and promotion

  - Develop and fund marketing strategies promoting alternative modes
  - Provide incentives and fund GRH programs
  - Provide incentives and fund association or network for transit or transportation coordination and management
  - Provide incentives to employers and individuals who encourage or use rideshare, van pools transit, and other alternative modes
  - Provide employer education and technical assistance, especially for large employers

Related Policies/Programs in Place

MTA’s 2001 Maryland Comprehensive Transit Plan (MCTP) calls for a doubling of transit ridership by 2020 from a 2000 baseline by increasing funding 42%.

The MDOT, in cooperation with the MPOs, MDE, and local government bodies has the following in place to promote transit use in the state:

- **Park-and-Ride spaces:** This strategy has been ongoing in Maryland since 1976. SHA, MDTA, and MTA will continue to implement additional Park-and-Ride spaces along the major roadways of the state.
- **State Highway Administration (SHA):**
  - 2005–2008, 1,408 new spaces
  - 2009–2012, 2,012 new spaces
  - 58% occupancy
  - SHA estimates 102,010,000 VMT reduced per year based on 11,745 spaces which exist today
- **Maryland Transit Administration (MTA):**
  - 2005–2008, 2,890 new spaces
  - 2008–2012, 2,475 new spaces
- **Expansion of Maryland Rail Commuter Service (MARC) and other transit services:** There is an understanding that there is a need to increase the supply of available transit service in Maryland.
  - MTA expects that there will be 10,000 additional MARC seats from added train sets and railcars by 2012.
  - Occupancy is conservatively estimated at 80%.

Type(s) of GHG Reductions

CO_2, methane (CH_4), and black carbon

Estimated GHG Reductions and Net Costs or Cost Savings

Data Sources:

Cambridge Systematics, Inc. 1999. Public transportation and the nation's economy: a quantitative analysis of public transportation's economic impact. Available at http://www.apta.com/research/info/online/documents/vary.pdf

J. Brown, D. Hess, and D. Shoup. 2003. Fare-free public transit at universities: an evaluation. *Journal of Planning Education and Research* 23:69–82.

J. Brown, D. Hess, and D. Shoup. 2001. Unlimited access. *Transportation* 28:233–267, Kluwer Publications.

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

L. Bailey. 2007 (Jan.). Public transportation and petroleum savings in the U.S.: reducing dependence on oil. ICF International. Available at http://www.icfi.com/Markets/Transportation/doc_files/public-transportation.pdf

D. Anderson, and G. McCullough. 2000. *The full costs of transportation in the Twin Cities region*. University of Minnesota. Available at http://www.cts.umn.edu/trg/research/reports/TRG_05.html

D.J. Forkenbrock, and G.E. Weisbrod. 2001. Guidebook for assessing the social and economic effects of transportation projects. TRB, National Cooperative Highway Research Program (NCHRP) Report 456.Available at http://www.trb.org

Quantification Methods:

GHG impacts:

TLU-3 would be funded with $2,768,000,000/year from the TLU-9 carbon fuel tax. That amount would be an 84% increase in total transit expenditures statewide.

Total transit ridership in Maryland in 2006 was 252,773,000 trips. An 84% increase in trips would produce an additional 212,329,000 trips. Put another way, we can simply assume an 84% increase in non-single-occupant vehicle (non-SOV) mode share. We take the latter approach and calculate the impacts of an 84% increase in non-SOV mode share.

Transit mode share in 2005 was 8.5%.

$$8.5\% \times 84\% = 7.14\%$$

Thus we analyze the impacts of an additional 7.14% transit mode share = a decrease in VMT of 7.14% by 2020. We ramp up from 2007 smoothly to the 2020 goal of an additional 7.14%.

Costs/cost savings:

The cost-effectiveness of investments in transit and transit promotion will vary depending on how those investments are made, and the Option language gives the state and its constituents a wide flexibility in making those investments. A given investment in transit and transit promotion may or may not produce net benefits, so while this process needs to make general policy recommendations, it will remain the responsibility of the state and its constituents to maximize the cost-effectiveness of investments made.

For the purposes of this analysis, and to give the MWG guidance, we ask whether those types of investments are *likely* to produce net costs or net savings. A wide variety of empirical experience suggests that the policies and investments listed in the Option Design and Implementation Mechanisms sections are likely to produce substantial *net savings,* as in the following four examples:

- *Transit investments generally*—Nationally, transit produces net economic returns on investment: "For every $10 million invested, over $15 million is saved in transportation costs to highway and transit users. These costs include operating costs, fuel costs, and congestion costs." These are in addition to the ancillary benefits summarized below.[7]

- *Transit fare initiatives*—Unlimited Access transit at the University of California, Los Angeles (UCLA) costs $810,000 a year and has total benefits of $3,250,000 a year.[8] Similar programs at other universities show similar results.[9] Universities are, in some senses, unique institutions, but the general types of challenges (especially demand for and cost of providing parking), and the types of benefits enjoyed in response to commute benefits programs, are equally available to businesses, even businesses located in what would normally be thought of as locations unsupportive of transit use. Deeply discounted bulk transit pass purchase programs, sometimes called "Eco Passes," offer an example. Under these, employers or schools purchase transit passes for 100% of their commuters or student population at a discount based on anticipated usage levels.

  > "Eco Passes also offer significant advantages for employers who offer free parking to all commuters, because those who shift from driving to transit will reduce the demand for employer-paid parking spaces. A survey of Silicon Valley commuters whose employers offer Eco Passes found that the solo-driver share fell from 76% before the passes were offered to 60% afterward. The transit mode share for commuting increased from 11% to 27%. These mode shifts reduced commuter parking demand by approximately 19%."
  >
  > "Given the high cost of constructing parking spaces in the Silicon Valley, each $1 per year spent to buy Eco Passes can save between $23 and $333 on the capital cost of required parking spaces."[10]

- *Transit and non-SOV options information and promotion*—Per public dollar, a Transportation Management Organization (TMO) can accommodate seven times as many commuters as new highway investment.[11]
- *Transit use*—Nationally,

  > "Households who use public transportation save a significant amount of money. A two adult "public transportation household" saves an average $6,251 every year, compared to an equivalent household with two cars and no access to public transportation service. We define "public transportation household" as a household located within ¾ mile of public transportation, with two adults and one car."[12]

As a bounding measure of benefits, one may use the most recent analysis of the full cost of a mile of auto travel in a U.S. urban area, which concluded that the total cost of a mile of auto

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[7] Cambridge Systematics, Inc. 1999. Public transportation and the nation's economy: a quantitative analysis of public transportation's economic impact. Available at: http://www.apta.com/research/info/online/documents/vary.pdf

[8] J. Brown, D. Hess, and D. Shoup. 2003. Fare-free public transit at universities: an evaluation. *Journal of Planning Education and Research* 23:69–82.

[9] J. Brown, D. Hess, and D. Shoup. 2001. Unlimited access. *Transportation* 28:233–267, Kluwer Publications.

[10] Ibid., 260.

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

[12] L. Bailey. 2007 (Jan.). Public transportation and petroleum savings in the U.S.: reducing dependence on oil. ICF International. Available at: http://www.icfi.com/Markets/Transportation/doc_files/public-transportation.pdf

travel was between $0.84 and $1.62, with a mid-range estimate of $1.14, in 2020.[13] That figure would give net savings of $2,570,164,781.

65,582,642,647	VMT
–7.14%	
= 4,682,600,685	VMT
× $1.14/mile	
= $5,338,164,781	
– 2,768,000,000	transit investment
= $2,570,164,781	**net savings in 2020**

The $1.14/mile is composed of the following costs:

- Internal to driver or owner are
  - Fixed vehicle,
  - Variable vehicle,
  - Travel time,
  - Other time,
  - Crashes, and
  - Parking and driveways.
- External to driver or owner are
  - Congestion,
  - Crashes,
  - Air pollution (health),
  - Air pollution (other),
  - Noise,
  - Fires and robberies, and
  - Petroleum consumption.

At a lower bound, one might do the same calculation using the current federal mileage reimbursement rate of $0.60/mile:

65,582,642,647	VMT
–7.14%	
= 4,682,600,685	VMT
× $0.60/mile	
= $2,809,560,411	
– 2,768,000,000	transit investment
= $41,560,411	**net savings in 2020**

Due to recent rapid increases in fuel prices, there are no good low bounds to use in this analysis. For example, during the MWG process, the American Automobile Association (AAA) cost per

[13] D. Anderson, and G. McCullough. 2000. *The full costs of transportation in the Twin Cities region*. University of Minnesota. Available at: http://www.cts.umn.edu/trg/research/reports/TRG_05.html

mile figure of $0.522/mile was from 2007: "Fuel prices in the study are based on the fourth quarter 2006 U.S. price for regular grade fuel, which averaged $2.256 per gallon…."[14] As of June 6, 2008, the AAA gives a national average price of $3.975/gal or 56% higher.[15] The Internal Revenue Service (IRS) mileage reimbursement rate does not include all relevant expenses. A price of $0.60/mile possibly underestimates even private costs and certainly underestimates total social costs. Thus, regardless of what the true cost per avoided mile is, transit investments of this magnitude will likely show net benefits.

How to characterize those benefits *per ton* is another challenge. *Savings per ton* behave very differently than do costs per ton. To give a simple example:

- If Maryland will *spend* a given amount and reduce emissions, the more emissions Maryland can reduce for that expense, the lower the cost per ton.
  - If Maryland were to spend $2.7 billion and reduce emissions by 2.8 million metric tons (MMt), the cost would be $964/ton.
  - If Maryland were to spend $2.7 billion and produce twice the benefit, reducing emissions by 5.6 MMt, the cost would fall by half, to $482/ton.
- But if Maryland will s*ave* a given amount and reduce emissions, the more emissions Maryland can reduce for that expense, the *lower* the savings per ton.
  - If Maryland were to save $2,570,164,781 (the estimated savings above) and reduce emissions by 2.8 MMt, the cost would be –$918/ton.
  - If Maryland were to save $2,570,164,781 (the estimated savings above) and double GHG reductions, reducing emissions by 5.6 MMt, the savings would fall by half, to –$459/ton.

In sum, for a given amount of savings, the higher the estimated emissions reduction, the less money per ton is saved. To exaggerate for the sake of argument:

- Say that Maryland invested the entire $2.7 billion in transit for purely economic and quality of life reasons, and happened to reduce a ton of emissions in the process. The savings would be $2.7 billion/ton.
- On the other hand, if Maryland made the same investment and made a wildly inflated estimate of 2.7 billion tons of emissions reductions, then it could estimate the savings at an apparently very reasonable $1/ton.

The bottom line is that characterizing the benefits of transit and multimodal investments in $ per ton is fraught with difficulty. Transit—and transportation generally—serves so many social goals that estimating its benefits has always been a difficult challenge.[16] Going another step and assigning those monetary benefits to a single-output measure, such as tons of emission reduction, risks further distorting the policy picture. "$ per ton" is a measure very well suited to evaluating

[14] http://www.aaanewsroom.net/main/Default.asp?CategoryID=4&ArticleID=529

[15] http://www.aaafuelgaugereport.com/

[16] D.J. Forkenbrock, and G.E. Weisbrod. 2001. Guidebook for assessing the social and economic effects of transportation projects. TRB, National Cooperative Highway Research Program (NCHRP) Report 456.Available at: http://www.trb.org

and comparing investments such as scrubbers that have explicit costs directly attributable to emissions reduction. Transit and transportation investments, unless made for the sole purpose of emissions reduction (such as various vehicle technologies), are not well evaluated using that kind of metric.

What then should policy makers do in a process like this one that uses $ per ton as an evaluation criterion? This analysis suggests that under a reasonable band of assumptions, a substantial Maryland investment in transit and multimodal transportation is almost certain—especially in an era of high and increasing fuel prices—to produce meaningful net savings for Maryland. Various people have characterized policies in this category as “no regrets policies” from a GHG perspective. One hesitates to use a phrase with such a political background, but the TWG—and then the MWG—might think about finding a phrase to describe policies that produce large non-GHG benefits, such that assigning all their benefits to GHG reduction produces numbers that are not useful in the policy-making process.

Counter-argument:

Not presenting and defending very high cost-effectiveness figures for transit and related investments incorrectly hides the large benefits available to society from those investments. In two examples given in the above discussion: (1) Unlimited Access transit at UCLA costs $810,000/year and has total benefits of $3,250,000/year; and (2) given the high cost of constructing parking spaces in the Silicon Valley, each $1/year spent to buy Eco Passes can save between $23 and $333 on the capital cost of required parking spaces.

The way for society to achieve that rate of return of “1 to 23” or “1 to 333” is to have the transit in place so that garages do not need to be built. Available benefits are empirically large, and should not be hidden behind a catchall phrase “net benefits.”

Cost-effectiveness:

$2,570,164,781 savings per 2.8 MMt = $917 per ton savings. The specific GHG emissions, costs and cost effectiveness are displayed in Table H-4.

Table H-4. TLU-3 Transit cost-effectiveness

Option No.	Policy Option	GHG Reductions ($MMtCO_2e$)			Net Present Value 2008–2020 (Million $)	Cost-Effective-ness ($/tCO_2e$)	Level of Support
		2012	2020	Total 2008–2020			
TLU-3	Transit	1.1	2.2	17.5	Net savings		Unanimous

GHG = greenhouse gas; $MMtCO_2e$ = million metric tons of carbon dioxide equivalent; $/$tCO_2e$ = dollars per ton of carbon dioxide equivalent.

Key Assumptions: The “Goals” statement above initially proposed “doubling transit service;” it is now “doubled transit ridership.” The initial assumption was that doubled provision would produce doubled ridership. The MTA analysis proposes to double ridership with a 42% increase in funding.

Key Uncertainties

Ability to expand transit service and ridership at the modeled pace.

Additional Benefits and Costs

Reducing VMT and increasing reliance on public transit will result in a reduced parking demand, lower household costs for transportation, decreased traffic congestion, improved air quality, reduced need and cost for roadway expansion, and improved health for new transit riders who walk or bicycle to transit.

Feasibility Issues

See "Key Uncertainties" about feasibility. On the other hand, the American Association of State Highway and Transportation Officials (AASHTO) has a goal of doubling national transit ridership by 2030.[17]

Status of Group Approval

Approved.

Level of Group Support

Unanimous.

Barriers to Consensus

None.

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[17] J. Horsley. 2008 (Jan.) Reauthorization and climate change. Available at: http://www.transportation.org/sites/aashto/docs/Horsley-2008-01-14.pdf

TLU-4. Low Greenhouse Gas Fuel Standard (LGFS)

Policy Description

A low greenhouse gas fuel standard (LGFS) would create a market-based program to reduce the GHG emissions from transport fuels and diversify transport fuel options for consumers.

The LGFS is designed to show no bias toward any particular fuel: it includes fossil and renewable fuels. Instead, the LGFS is meant to require fuel providers to reduce the GHG intensity of the fuels they sell in Maryland. "Fuel providers" are identified as producers, importers, refiners, and blenders.

The LGFS is not a tailpipe standard for GHGs. The LGFS considers GHG emissions on a full fuel-cycle basis, which includes not only tailpipe emissions, but also emissions associated with the production and distribution of fuels (well to wheels [WTW]). This will result in varying carbon impact values for fuels that would otherwise look the same to customers.[18] It is essential to the success of this policy option that it is implemented at a regional level. In terms of GHG reductions and cost-effectiveness, effective coordination with nearby states is imperative.

Policy Design

Goals: Implement policy that reduces the average carbon intensity of on-road transportation fuel 5% by 2020. This was revised down from 10% based on the uncertainty surrounding the GHG emissions reductions that can be expected from the biofuels currently available on the market. Additionally, proposed implementation mechanisms should emphasize use of fallow land or waste feedstocks to produce the biofuels.

Timing: Longer term.

Parties Involved: All layers of government, and fuel providers.

Implementation Mechanisms

- Partnership with the MDOT to create the framework for the LGFS.
- Market-based mechanisms for fuel providers to choose how they wish to meet LGFS.
- Full life-cycle basis of measuring GHG impact of transportation fuels. Implemented by a cap-and-trade (C&T) system for fuel providers.
- Financial incentives for refueling station creation and retrofitting based on LGFS.
- Certification process.
- To the extent practicable, harmonize with any Northeast States for Coordinated Air Use Management (NESCAUM) proposal or the California LCFS.

[18] For example, how ethanol is made affects its life cycle GHG profile substantially.

Related Policies/Programs in Place

Currently, about 85% of Maryland's gasoline supply contains 10% ethanol (E10), which has been added to federal reformulated gasoline to replace methyl tert-butyl ether (MTBE). Other sources of biofuels are three stations in the state dispensing a blend of 85% ethanol and 15% gasoline (E85) to the public and eight retail outlets and 10 distribution facilities offering bio-diesel. Maryland requires that at least 50% of state vehicles must use a minimum bio-diesel blend of 5% bio-diesel fuel (B5) beginning in fiscal year 2008.

The Energy Policy Act of 1992 (EPAct) required federal and state governments to purchase alternative-fuel vehicles (AFV), and in 2001, a Maryland Executive Order was signed requiring state vehicles use flexible fuel at least 50% of the time. The State of Maryland owns approximately 800 flexible-fuel vehicles (FFVs), few of which use E85. However, under current mandates at least 50% of diesel-fueled vehicles in the state's fleet are required to use a blend of fuel that is at least B5. The state is currently meeting this B5 requirement in its fleets. The state expects to be at the B20 level by 2012.

U.S. refiners and importers were required to use 4.7 billion gallons of biofuels. However, 6.85 billion gallons of ethanol were used as a transportation fuel in 2007, exceeding the federal mandate. In December 2007, the U.S. Congress passed the Energy Independence and Security Act of 2007 (EISA). The EISA included a significantly increased renewable fuel standard containing four interrelated parts consisting of an overall mandate and set asides for advanced, cellulosic, and biomass diesel. These mandates incorporate life cycle GHG-reduction requirements. The overall mandate starts in 2008 at 9.0 billion gallons, and grows to 36 billion gallons in 2022. In 2009, the individual mandates begin to phase-in.

The Renewable Fuels Promotion Act of 2005 authorizes the payment of credits to producers of Maryland-originating ethanol and bio-diesel that meet certain requirements. The amount of credit paid to producers would depend on the number of qualifying plants and whether the feedstocks would qualify for a $0.05 or $0.20/gal credit. The law also established a Renewable Fuels Incentive Board to review claims and pay credits to producers over a 10-year period. Beginning in fiscal year 2008, once a facility is certified, the Governor must include funds to implement the credit program. To date, no facility in Maryland has been certified.

Chapter 425 of 2006 SB 54)—this requires that at least 50% of diesel-fueled vehicles in the state vehicle fleet (with the exception of vehicles whose manufacturers warranties would be voided if the use of bio-diesel caused mechanical failure) use at least B5 fuel, beginning in fiscal year 2008. The effects of this legislation are just beginning to be felt, but it appears that the state is successfully meeting the requirements of the bill.

Chapter 623 of 2007 (HB 745)—this requires that, beginning in fiscal year 2009, at least 50% of the state's heavy equipment, off-road equipment, and heating equipment that uses diesel fuel must use at least B5 fuel, subject to its availability. According to the bill's fiscal and policy note, this resulted in increased state expenditures (all funds) of $177,600 in fiscal year 2009, reflecting a $0.05/gal price premium for B5 fuel for heating and heavy equipment. According to the Maryland Department of Budget and Management (DBM), the state purchases 9.5 million gallons of diesel annually. The two largest state consumers of diesel fuel are the MTA, which uses 8 million gallons of diesel fuel annually in 800 buses, and the SHA, which uses 750,000 gallons. These two agencies consume 92% of diesel fuel purchased by Maryland state agencies.

Under the terms of this bill, MTA would use 4 million gallons of B5 fuel annually to run half of its fleet, and SHA would use 375,000 gallons. In total, the state would purchase 4.75 million gallons of B5, nearly all of it with Transportation Trust Fund (TTF) dollars. This equates to a market for approximately 240,000 gallons of bio-diesel. The state anticipates having no difficulty meeting the mandates of this legislation.

Type(s) of GHG Reductions

All GHG types in the fuel life cycle.

Estimated GHG Reductions and Net Costs or Cost Savings

Table H-5 displays the difference between the no-action trend and implementation of the California low GHG gas fuel standard.

Table H-5. Comparison of no action trend and California low greenhouse gas fuel standard (LGFS)

	$MMtCO_2e$		
	2005	2015	2020
No-action trend (Light-duty + heavy-duty)	23.94 + 5.89 = 29.83	26.97 + 7.91 = 34.88	28.78 + 9.18 = 37.96
CA LGFS – 5% by 2020		33.73	36.06
Reduction		1.1	1.9

LGFS = low greenhouse gas fuel standard; $MMtCO_2e$ = million metric tons of carbon dioxide equivalent; CA = California.

Under the LGFS, fuel providers would be required to track the global warming intensity (GWI) of their products, measured on a per-unit-energy basis, and reduce this value over time. GWI is a measure of all of the mechanisms that affect global climate including not only GHGs, but also processes (like land-use changes that may result from biofuel production). The term *life cycle* refers to all of the activities included in the production, transport, storage, and use of fuel. The unit of measure for GWI used in this study is carbon dioxide equivalent per megajoule (gCO_2e/MJ) of fuel delivered to the vehicle, and adjusted for inherent differences in the in-use efficiency of different fuels (e.g., diesel, electricity, and hydrogen).

The table below is from the University of California (UC) analysis of the LGFS. It shows the global warming impacts by fuel estimated by two different life cycle analysis (LCA) models. Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation (GREET) is a model developed by Argonne National Laboratory (ANL) for the U.S. Department of Energy (US DOE). The GREET model is the primary tool relied upon in the UC study. While Lifecycle Emissions Model (LEM) has been under development for several years, it remains unfinished today, so some of the qualified impacts are best characterized as illustrative of rough magnitudes under certain sets of assumptions. However, LEM is more comprehensive than many other LCA models.

Note that very recent research published in *Science* (Fargione, et al., 2008) provides different evidence than the UC study from which the information that follows on GWIs was developed. The Fargione paper says that while biofuels can offer carbon savings, this is dependent on how they are produced. Converting grasslands, peatlands, or savannas to produce food-based biofuels in Brazil, Southeast Asia, and the United States creates a biofuel carbon debt be releasing 17 to 420 times more CO_2 than the annual GHG reductions these biofuels provide by replacing fossil fuels. In contrast, biofuels made from waste biomass, or from biomass grown on abandoned agricultural lands planted with perennials incur little or no carbon debt and offer immediate and sustained GHG advantages.

A second *Science* article (Searchinger, et al., 2008) notes that most prior studies of biofuels have failed to count the carbon emissions that occur as farmers worldwide respond to higher prices, and convert forest and grassland to new cropland to replace the grain (or cropland) diverted to biofuels. Using a worldwide agricultural model to estimate emissions from land-use change, they found that corn-based ethanol, instead of producing a 20% savings, nearly doubles GHG emissions over 30 years, and increases GHGs for 167 years. Biofuels from switchgrass, if grown on U.S. corn lands, increase emissions by 50%. This result raises concerns about large biofuel mandates and highlights the value of using waste products.

U.S. Environmental Protection Agency (US EPA) will propose life cycle GHG reductions as part of its responsibility under EISA. These emission reduction estimates will take into account the concerns raised in these *Science* articles. The US EPA plans to issue these regulations during 2009.

Table H-6 illustrates two important points: (1) the wide range of GWI values for motor vehicle fuel alternatives, and (2) the level of uncertainty in estimated GWI values for any specific fuel (as seen by the difference between the GREET and LEM model GWI estimates for individual fuels).

Table H-6. Global warming impacts estimated by two life cycle analysis (LCA) models (gCO_2e/MJ)

Fuel	Fuel production pathway	GREET	LEM (CEF)
CA RFG	Marginal gallon produced in CA	92	85
Diesel	Ultra-low-sulfur diesel produced in CA	71	73
Propane	From petroleum	77	67
CNG	From North American natural gas (in spark ignition engines)	79	81
BTL	Fischer-Tropsch (F-T) diesel from California biomass (poplar trees)	–3	–
CTL	F-T diesel from coal	167	–
Bio-diesel	FAME bio-diesel from Midwest soybeans	30	224
Ethanol	Midwest corn ethanol from a coal-fired dry-mill	114	–
Ethanol	Midwest corn ethanol from a natural gas-fired dry-mill	70	97
Ethanol	Midwest corn ethanol using stover as fuel in a dry-mill	47	–
Ethanol	California corn from a gas-fired dry-mill, wetcake coproduct	52	–
Ethanol	Cellulosic ethanol from California poplar trees	–12	–
Ethanol	Cellulosic ethanol from Midwest prairie grass	7	–
Ethanol	Cellulosic ethanol from municipal solid waste	5	–
Electricity	CA average electricity	27	–
Electricity	Natural gas combined cycle and renewable generation	21	34
Hydrogen	Hydrogen from biomass, delivered by pipeline	22	–
Hydrogen	Hydrogen from steam-reformation of onsite natural gas	48	26

LCA = life cycle analysis; gCO_2e/MJ = grams of carbon dioxide equivalent per megajoule; GREET = Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation; LEM = Lifecycle Emissions Model; CEF = carbon emission factor; CA = California; RFG = reformulated gasoline; CNG = compressed natural gas; BTL = biomass to liquids; F-T = Fischer-Tropsch; CTL = coal to liquids; FAME = Fatty Acid Methyl Ester.

Table H-7 below summarizes the LDV scenarios that were evaluated in the California low-carbon fuel standard study. This table compares the baseline scenario of continuing use of existing fuel and vehicle technologies with various fuel and vehicle innovations. While the LGFS could be met, in part, by vehicle technology innovations, it is suggested that the scenarios of most interest to Maryland should be the two labeled: (1) existing vehicles with advanced biofuels, and (2) biofuel intensive. For these two scenarios, D10 and G10 represent the 10% reduction goal. (Perhaps confusingly, these designations are simply identifiers, not abbreviations like B10 for 10% bio-diesel.)

The D10 scenario includes two types of advanced biofuels for LDVs, low GHG biofuel blends with gasoline and low GHG Fischer-Tropsch (F-T) diesel blends. This scenario minimizes changes to the fuel delivery infrastructure, including the equipment to ship biofuels into and within the state and at retail stations. This scenario avoids the use of E85. Attaining a 10% AFCI reduction by 2020 requires some biofuels with performance better than the identified low GHG fuels (cellulosic ethanol from switch grass or Midwest prairie grass). Unfortunately, these are controversial, and it is not clear that such fuels are technically feasible. An alternative is to increase the fraction of biofuel blended with gasoline.

The G10 scenario is designed to explore potential outcomes that require as little fuel and vehicle innovation as possible, and instead rely mostly on large volumes of mid-GHG biofuels in low blends (10% by volume in gasoline and 10% bio/renewable diesel) and high blends (85% volume in gasoline).

Table H-7. Light-duty vehicle (LDV) scenario names, descriptions, and AFCI goals

Scenario Name	Fuel Innovations	Vehicle Innovations			
			–5%	–10%	–15%
Baseline	Current technologies	Gasoline ICE dominates Increased diesel, HEVs	A*		
Electric Drive	Electric charging and H2 refueling	Significant innovation in PHEV, EV, and FCV technologies	C5	†	†
Existing Vehicles with Advanced Biofuels	Significant biofuel innovation Low-GHG biofuels (5.7% vol.) Low-GHG F-T diesel blends	None required	D5	D10	†
Evolving Biofuels and Advanced Batteries	No fuel innovation Mid-GHG biofuels (10% vol.) Mid-GHG bio-diesel blends	Advances in PHEV, EV, and FCV technologies.	F5	F10	†
Biofuel Intensive	No fuel innovation Mid-GHG biofuels (10%, 85%) Mid-GHG bio-diesel blends Low-GHG fuels for G15	None required	G5	G10	G15
Multiple Fuels and Vehicles	Low-GHG biofuels (10%, /85%) Low-GHG F-T diesel blends Electric charging and H2 refueling	Advances in PHEV, EV, and FCV technologies	H5	H10	H15
Heavy-Duty Compliance	To be determined	To be determined			

LDV = light-duty vehicle; AFCI = Average Fuel Carbon Intensity; ICE = internal combustion engine; HEVs = hybrid electric vehicles; PHEV = plug-in hybrid electric vehicles; EV = electric vehicle; FCV = fuel cell vehicle; GHG = greenhouse gas; F-T = Fischer-Tropsch.

* No Average Fuel Carbon Intensity (AFCI) goal applies.

† Not considered.

NOTES: No "B" or "E" scenarios are used to avoid confusion with bio-diesel and ethanol blends.

In the "No fuel innovation" scenarios, investment is needed to increase the use of current technologies, but no new technologies are assumed. Biofuel scenarios that assume energy crop production for mid-GHG ethanol (F and G scenarios) have large uncertainties due to feedstock production. See Section 2.4.

The incremental long-term cost of bio-diesel is estimated to be $0.20/gal above the cost of petroleum diesel. Maryland 2020 on-road diesel usage is expected to be 837 million gallons. If 20% of the petroleum diesel gallons are replaced with bio-diesel, then the added consumer cost in Maryland during 2020 is $33.5 million. Diesel CO_2 emission reductions in a 10% reduction scenario are 0.998 MMt. The cost-effectiveness of these diesel emission reductions therefore would be $33.5 dollars per ton of carbon dioxide equivalent ($/t$CO_2$e).

For F-T diesel, recent analyses have estimated the F-T diesel costs $0.15 more than conventional diesel. This is based on California Energy Commission (CEC) reports stating that the analysis of a mature market assumes that the incremental cost of F-T fuel is $0.15/gal higher than US EPA diesel at the refinery gate.

Based on 2007 U.S. prices, the cost per gallon for gasoline is $3.03/gal, while the cost for ethanol as E85 is $3.71 (to get the energy equivalent of a gallon of gasoline). The gasoline cost analysis reviewed the 2020 gallons of gasoline equivalent projections of LDV fuel use by fuel type for the D10 and G10 scenarios in California. The G10 scenario was ultimately used for this cost analysis because it included the largest penetration of E85. The California analysis showed a 14% statewide reduction in gasoline usage, with most of these gallons replaced with either E85 or an ethanol blend. A 14% reduction in 2020 gasoline gallons in Maryland is 376 million gallons. The cost of achieving this gasoline displacement is $255 million at a $0.68 price differential per gallon. A 10% reduction in gasoline-associated carbon is estimated to yield a 2.878 MMt reduction in carbon dioxide equivalent (CO_2e). The associated cost-effectiveness is $88.6 per metric ton.

Data Sources:

"Maryland Task Force on Renewable Alternative Fuels, Final Report," December 31, 2007.

A. Farrell and D. Sperling. 2007. A low-carbon fuel standard for California, part 1: technical analysis. UC Berkeley and UC Davis. UCB-ITS-TSRC-RR-2007-2. Available at: http://repositories.cdlib.org/its/tsrc/UCB-ITS-TSRC-RR-2007-2/

J. Fargione et al. 2008. Land clearing and the biofuel carbon debt. *Science* 319:1235–1238.

T. Searchinger et al. 2008. Use of U.S. croplands for biofuels increases greenhouse gases through emissions from land-use change. *Science* 319:1238–1240.

Quantification Methods: Above.

Key Assumptions: Current costs of biofuels are representative of the long-term price differences compared with petroleum-based fuels.

Key Uncertainties

There is considerable uncertainty in the future price of gasoline and petroleum diesel, as well as the lower carbon alternatives to these transportation fuels. There is uncertainty in AFCI values for the alternatives to petroleum fuels. There is also uncertainty in the ability of the market to deliver lower carbon fuels. Cost estimates for biofuels, such as bio-diesel and F-T diesel, are based on long-term expectations, but are highly uncertain.

Additional Benefits and Costs

These depend on the compliance pathway(s) that the marketplace uses to meet the LCFS.

Feasibility Issues

See "Key Uncertainties."

Status of Group Approval

Approved.

Level of Group Support

Unanimous.

Barriers to Consensus

None.

TLU-5. Intercity Travel: Aviation, Rail, Bus, and Freight

Policy Description

Provide transportation infrastructure between cities to create connectivity of non-auto, non-truck transportation modes. Rail transport is one of the most energy-efficient means to move people and freight over commonly traveled routes on land. Modern rail can also provide a competitive, low-GHG alternative to short-range air travel. Movement of passengers and freight by an efficient rail system decreases overall GHG emissions by 2 to 4 times as compared with movement by highway. Increased rail capacity would shift freight from trucks to rail.

Technology-based improvements, such as anti-idle devices and more efficient engines, will reduce direct emissions from the locomotives operating on the rail network. A robust and efficient rail network using modern, efficient technology is a cornerstone for sustaining Maryland's thriving economy under future carbon emission constraints, while providing many social, economic, and environmental benefits.

Policy Design

Goals:

Reduce transportation sector GHG emissions from intercity travel by making passenger and freight rail more accessible, efficient, and available via

- Building capacity of express rail and bus by expanding or improving current passenger and freight rail as needed,
- Marketing of new and improved or expanded services,
- Shift short and mid-distance air travel to modern rail, and
- Support auto-free tourism development in Maryland.

In particular, implement the recommendations of the Mid-Atlantic Rail Operations (MAROps) Study[19] to address bottlenecks in Maryland and through out the I-95 Corridor. The recommendations include near-, medium-, and long-term actions items and improvements. For Maryland, the improvements and actions items are

- *Near-Term Program:* Design for reconstruction of the Howard Street Tunnel and approaches on the rail network; connection between Amtrak Penn Line and CSX Camden Line to serve MARC; second and third main track on CSX from West Baltimore to Washington, D.C.; clearance projects (17 locations) on CSX north from Baltimore; rehabilitation of Amtrak's Gunpowder, Susquehanna, and Bush River bridges; design for reconstruction of Amtrak's Union Tunnels and Baltimore and Potomac (B&P) Tunnel; dedicated freight track to eliminate Norfolk Southern (NS) passenger train conflicts between Perryville and Baltimore, Maryland; and second main track on NS from the Pennsylvania/Maryland state line to Berryville, Virginia.

[19] Cambridge Systematics, Inc. 2004 (Mar.). MAROps study: interim benefits report. Prepared for 1-95 Coalition. Available at: http://66.167.232.132/pm/projectmanagement/Upfiles/reports/full240.pdf

- *Medium Term Project:* Second main track on CSX from the Delaware/Maryland state line to Baltimore; reconstruct the Howard Street Tunnel and approaches on CSX; construct new freight bridges over the Gunpowder, Susquehanna, and Bush rivers to eliminate NS/passenger conflict; and reconstruct Amtrak's Union Tunnels and B&P Tunnel.
- *Long Term Project:* Reconfigure existing tracks on Amtrak from West Baltimore to Baltimore Washington International Airport (BWI); construct new passenger station at BWI; and construct fourth main track from Halethorpe to Landover to eliminate freight/passenger train conflicts.

Maryland should also closely examine proposals by the National Association of Rail Passengers (NARP) and by America 2050,[20] which propose substantial investments in passenger rail transit. It is beyond the scope of this process to examine those in detail and quantify their potential impact in Maryland.

Timing: Timing of the programs recommended by the MAROps Study is as follows: near-term program by 2009; medium-term program from 2009–2014; and long-term program from 2014–2024.

Parties Involved: Public and private.

Other: Remove capacity constraints through the Baltimore area that restrict use of double stack rail cars that are of limited capacity

Implementation Mechanisms

Implementation details include

- Building capacity of express rail and bus by expanding or improving current passenger and freight rail as needed.
  - Planning:
    - Work with municipalities to plan and regulate land use to accommodate well-connected rail and bus infrastructure and service; and
    - Work with Maryland tourism industry to launch car-free tourism initiatives and promotion strategies.
  - Capital/Infrastructure:
    - Improve rail infrastructure to serve all freight needs (e.g., double-stack);
    - Provide adequate inter-modal (e.g., transit, bike, pedestrian, shuttle bus, bike-sharing, car-sharing) connections at railroad stations, airports, and major bus stops; and
    - Identify and provide necessary freight modal transfer stations throughout Maryland.
  - Operating:
    - Improve the frequency of service and travel time of current express train and bus routes; and

[20] http://www.america2050.org/pdf/America2050prospectus.pdf

  - Extend service to underserved cities and regions of Maryland, if and as warranted by demand analysis

- Standardize the use of anti-idle equipment and best practices for locomotives.
  - Increase the number of modern, more fuel-efficient locomotives in service (e.g., Diesel Multiple Units [DMUs]).
  - Develop electrified rail support systems, and hybrid or fully electric locomotives where cost-effective.
  - Adopt incentives and regulations to ensure timely adoption of high-efficiency, low-polluting freight, passenger, and port equipment statewide.
- Marketing of new and improved or expanded services.
  - Target improved railroad station and airport inter-modal connections to large institutions and companies, as well as the Maryland travel industry.
  - Develop an auto-free tourism initiative through the agency of Maryland government such as the Maryland Office of Tourism or Maryland Tourism Development Board that engage in tourism promotion, in cooperation with MDOT. Develop program investments and public-private partnerships and incentives to support these initiatives.

Related Policies/Programs in Place

None cited.

Type(s) of GHG Reductions

CO_2 and fine particulates from diesel.

Estimated GHG Reductions and Net Costs or Cost Savings

Data Sources:

U.S. Department of Transportation (US DOT). 2006 (Aug.). Guide to quantifying the economic impacts of federal investments in large-scale freight transportation projects. Available at http://www.dot.gov/freight/guide061018/index.htm

VMT from the Maryland GHG Inventory and Forecast Projections.

Quantification Methods:

GHG Reductions:

We calculate average emissions per mile for heavy-duty vehicles (HDV) for each year from 2010 to 2020. The VMT reductions anticipated for freight from improved alignments as well as new tunnels beneath the City of Baltimore and alternative alignments to bypass the city is reported in “Case Study: Baltimore Freight Rail Bypass” (chapter 8.2) of the “Guide to Quantifying the Economic Impacts of Federal Investment in Large-Scale Freight Transportation Projects.” Freight VMT reductions from just this one improvement project are reported as nearly 426,000 trucks or 143 million miles in 2010, and 866,000 trucks or over 560 million miles by 2039. Multiplying the anticipated reduction in heavy-duty miles with the projected average emissions per miles, the emissions reductions that can be anticipated for reduced HDV VMT are 0.2

$MMtCO_2e$ in 2012, and 0.3 $MMtCO_2e$ in 2020. The anticipated total reduction in $MMtCO_2e$ from 2012 to 2020 is 1.9 $MMtCO_2e$.

Because these emissions reductions are for implementing only the MAROps recommendations, and the Policy Option recommends broader improvement of freight and passenger infrastructure and operations in Maryland, this is reported as a low-end estimation of the possible VMT reductions that are available from improving intercity rail.

Net Present Value and Cost-effectiveness:

The "Case Study: Baltimore Freight Rail Bypass" reports that an improved rail system would cost $3.05 billion over the 2-year period to build the project, and for operating and maintenance costs through 2035. The improved rail system would have benefits in Maryland of $2.06 billion and $4.73 in national benefits. These benefits take into consideration freight rail operator benefits, shipper costs, Amtrak, highway benefits, and supply chain benefits.

Key Assumptions:

The freight VMT miles, from the Case Study: Baltimore Freight Rail Bypass," assumes that freight trips, originating or terminating in Maryland, travel 300 miles on average, while through trips would travel an average of 500 miles.

Key Uncertainties

None cited.

Additional Benefits and Costs

None cited.

Feasibility Issues

None cited.

Status of Group Approval

Approved.

Level of Group Support

Unanimous.

Barriers to Consensus

None.

TLU-6. Pay-As-You-Drive (PAYD) Insurance

Policy Description

PAYD insurance ties a substantial portion of consumer insurance costs to a variable cost with respect to actual motor-vehicle travel use, so premiums are more directly related to hours or miles driven, with adjustment for other rating factors, such as driving record, age, and the vehicle driven. PAYD makes insurance more actuarially accurate and allows motorists to save money when they reduce their vehicle use and drive more calmly. Miles driven is only a minor rating factor in current insurance policy pricing.

Consider if all drivers paid a fee for gasoline every six months based on the average driver's fuel consumption. That is akin to how insurance is now priced. Compare this with a system in which drivers pay only for the gasoline they actually use, and get to save money if they drive less. That is similar to the idea of PAYD insurance, where the policyholder saves more if he or she drives less

Policy Design

Goals:

PAYD coverage *available* to all Maryland drivers by 2010, with 10% of Maryland drivers adopting such policies by 2012 and 100% adopting by 2020, by implementing the following:

- Conducting a review of opportunities and barriers;
- Converting all Maryland Automobile Insurance Fund policies to PAYD;
- Initiating state-sponsored pilot programs, with state-level incentives for insurance companies to offer PAYD policies that reduce GHG emissions; and
- Phasing in a requirement that carriers offer PAYD policies as part of their Maryland product choices.

Timing: Establish Task Force by June 2008 to develop recommendations for administrative, regulatory, and statutory action, with preliminary report by November 30, 2008, and final report to Governor and Legislature by March 1, 2009. Initiate pilot programs, marketing, industry outreach, and administrative, regulatory, and statutory actions in 2009–2010.

Parties Involved: Insurance Commissioner, insurance companies, MDOT, Secretary of Transportation, consumer groups, and environmental advocates

Implementation Mechanisms

- The Governor should convene a "Motor Vehicle Insurance and Climate Change Task Force" to develop preliminary recommendations for the Governor and Legislature by November 30, 2008, and final recommendations by March 1, 2009, on initiatives and options that might reduce GHG emissions from transportation through usage-based pricing of motor vehicle insurance.

- The Governor, State Insurance Commissioner, Maryland Motor Vehicle Administrator, Legislature, and other key actors should initiate coordinated state sponsored pilot programs, insurance industry outreach, regulatory measures, and state-level incentives for insurance companies to offer PAYD policies, designing a program that will result in GHG emission reductions consistent with x goals adopted by the Maryland Climate Change Commission (MCCC).
- The Governor should work with the Legislature to ensure state insurance regulations are supportive of timely widespread availability for all Maryland motorists of PAYD insurance policies designed to contribute to meeting GHG-reduction goals.

To design this coordinated set of implementation actions, a "Motor Vehicle Insurance and Climate Change Task Force" should be convened by the Maryland Governor. This should be composed of the Maryland Insurance Commissioner, Maryland Motor Vehicle Administrator, and Maryland Secretary of the Environment. The panel should develop preliminary recommendations for the Governor and Legislature by November 30, 2008, and final recommendations by March 1, 2009, on initiatives and options that might reduce GHG emissions from transportation through usage-based pricing of motor vehicle insurance consistent with the goals of the MCCC. The panel should include a balanced mix of representatives from the insurance industry, consumer groups, and environmental stakeholders. The reports should identify different options and their potential to contribute to GHG reductions, consistent with goals articulated by the MCCC. The reports should include the implementation details listed below.

- Conducting a review of possibilities for changes in factors determining motor-vehicle insurance rates that might align these more closely to measured motor vehicle usage, thereby better enabling consumers to save money by modifying their amount of driving, behavior, and fuel consumption.
- Payment mechanisms to be considered include:
    - Insurance type
        - Discrete premium levels, where premiums are set within specific ranges for mileage driven, given other rating factors;
        - Pay by the mile, using a linear or non-linear rate that increases as mileage increases; or
        - Pay based on hours or miles driven, with adjustment for time, location, speed, and aggressiveness of driving style, given other rating factors.
    - Pricing options
        - Fixed up-front pricing with a re-imbursement (or additional payment) at the end of the policy period;
        - Shorter policy periods (e.g., 1 month, instead of 6 to 12 month period), to be billed in a manner similar to utilities; or
        - Purchased insurance is valid up to a certain mileage, instead of or until a particular date.

- Technology options—Review applicable technologies for real-time, occasional, or periodic consumer feedback on how motor vehicle usage affects consumer insurance costs, including:
  - Periodic certified odometer readings,
  - Periodic upload of on-board vehicle computer data,
  - In-vehicle real-time global positioning system- (GPS) based meters with periodic reporting, or
  - Pay-at-the-pump technologies.
- Regulatory, promotion, and implementation options to be considered include:
  - Voluntary market-driven strategies to encourage PAYD policies;
  - Identifying regulatory and market barriers to PAYD policies in Maryland, and changes needed to eliminate these;
  - Identifying regulatory measures that could be taken to ensure 100% of Maryland drivers are offered timely PAYD policies designed to maximize reduce GHG emissions;
  - Tax credits and other incentives that could accelerate the timely adoption of PAYD policies to meet GHG emission reduction goals; or
  - Federal and state transportation funding that might support pilot programs, promotion and marketing, planning, industry outreach and incentives, research, monitoring, and evaluation related to the goals of this initiative.

Related Policies/Programs in Place

GMAC and OnStar Offers Low-Mileage Discount Rates[21]

Since mid-2004, the General Motors Acceptance Corporation (GMAC) Insurance has offered mileage-based discounts to OnStar subscribers located in certain states. The system automatically reports the vehicle odometer reading at the beginning and end of the policy term to verify vehicle mileage. Motorist who drive less than specified annual mileage receive insurance premium discounts of up to 40%. These are higher than the standard industry discounts, but fall well short of the full marginal-cost insurance pricing needed to achieve envisioned PAYD GHG-reduction goals:

Miles	Discount
1–2,500	40%
2,501–5,000	33%
5,001–7,500	28%
7,501–10,000	20%
10,001–12,500	11%
12,501–15,000	5%
15,001–99,999	0%

[21] See http://www.onstar.com/us_english/jsp/low_mileage_discount.jsp

Value Pricing Program Government-Supported PAYD Pilot Projects [22]

This Federal Highway Administration's (FHWA) Value Pricing Pilot Program has made over $4 million in funding for PAYD pilot projects in Georgia and Washington State. The Puget Sound region's PAYD pilot project is now moving forward most expeditiously. The Dallas-Ft. Worth MPO has made available $2 million in regional transportation funding for a PAYD pilot program. These initiatives are designed to help assist the insurance industry in evaluating how best to advance PAYD policies.

Use-Based Insurance Program

Progressive Insurance[23] currently offers policies with small distance-based insurance discounts in Oregon, Michigan, and Minnesota. The program uses a device that reads on-board diagnostics from participating vehicles and provides drivers a means to transmit this data, at their discretion, via the Internet to Progressive.

"Safer drivers and people who drive less than average should pay less for auto insurance. That's why we created the revolutionary TripSenseSM discount program, which measures your actual driving habits and allows you motorists to earn discounts on your insurance by showing us the insurer "how much, how fast and what times of day you drive." According to Progressive, "TripSenseSM gives you more control over what you pay for insurance, as your driving habits determine your discount." [24]

From 1998 to 2001, which was prior to the current Dallas-area pilot with Progressive and to the TripSenseSM Program, Progressive piloted PAYD insurance with over 1,200 Texas drivers whose vehicles were equipped with GPS devices. Individualized premiums under this "Autograph" program were primarily based on the amount of time people drove, when and where they drove, and included a small fixed charge.

Each of the programs discussed above offer mileage-based discounts or premiums that go beyond the current standard practice in the insurance industry in which there is little or no discount for driving less, and little or no extra charge for driving more under a given insurance policy. Several insurance companies, including Progressive, will expand offerings for PAYD insurance products in the near future.

According to the *New York Times* (April 20, 2008), new research by Brookings Institution authors Jason Bordoff and Pascal Noel,

> makes a compelling case that PAYD insurance would work well, reducing the carbon emissions, congestion and accident risk created by too much driving while leading drivers to pay the true cost of their mileage. Bordoff and Noel put the total social benefit at $52 billion a year.
>
> The better news is that PAYD insurance is no longer just an academic exercise. G.M.A.C. has begun using OnStar technology to offer mileage discounts, and next month Progressive will roll out a comprehensive PAYD plan called MyRate. Progressive, the huge Ohio-based insurer that has long prided itself as an innovator, will first offer the plan in six states, having run a similar pilot in three other states. Drivers who sign up for MyRate will install a small wireless device in their cars that

[22] See http://www.fhwa.dot.gov/policy/13-hmpg.htm

[23] See http://www.progressive.com

[24] See http://tripsense.progressive.com/about.aspx

> transmits to Progressive not just how many miles they drive but also when those miles are driven and, to some extent, *how* they are driven: the device measures the car's speed every second, from which Progressive can derive acceleration and braking behavior. Which means that Progressive will not only be able to charge drivers for the actual miles they consume but will also better assess the true risk of each driver.

Maryland is a state where Progressive has been actively exploring PAYD policies, and in which it's highly probable that MyRate will be offered soon.

Type(s) of GHG Reductions

Predominantly CO_2.

Estimated GHG Reductions and Net Costs or Cost Savings

Data Sources:

The Arizona Public Interest Research Group (PIRG) Education Fund analyzed the potential GHG savings from a PAYD automobile insurance policy. The strategy for a PAYD policy analyzed assumes that insurers are required to offer mileage-based insurance for certain elements of vehicle insurance, including collision and liability. The PIRG Education Fund assumes the PAYD policy is required, phased in over time, and that all drivers in Arizona are eventually covered.

To calculate GHG savings, PIRG converted Arizona State automobile collision and liability insurance expenditures to an insurance cost per mile ($0.064/mile). If insurance consumers pay 80% of their collision and liability insurance on a per-mile basis, then drivers would be assessed about a $0.051 charge per mile. This per-mile insurance charge would reduce VMT by about 8%.[25] To put this PAYD pricing in context, at 20 miles/gal, the effect of a $0.051/mile savings is equivalent to a savings of about $1/gal of gasoline.

CCS compared the PIRG Education Fund results for estimated reductions in VMT with other studies of PAYD policies, including those produced by the Economic Policy Institute (EPI) and Resources for the Future (RFF). CCS found that the Arizona PIRG estimates were comparable with other estimates, which ranged from 8% to 20%.

Quantification Methods:

Impacts:

- Pilot studies, and empirical experience with other marginal costs of use, find that PAYD can reduce VMT by between 8% and 20%, therefore if phase in/ramp-up, then
- Apply reductions to LDV VMT only
- 2012 reduction = statewide LDV * 4% reduction (assuming voluntary PAYD with only partial mileage based discounting and no real-time driver feedback on driving style)
- 2012–2020 reduction = statewide LDV * 15% reduction (assuming full mandatory PAYD pricing with real-time driver feedback to encourage calm driving for all motor vehicle classes; benefits derive from reduction in VMT and reductions in emission rates per mile

[25] E. Ridlington and D.E. Brown. 2006 (Apr.). A blueprint for action: policy options to reduce Arizona's contribution to global warming. Arizona PIRG Education Fund, pp. 25–26. Available at: http://www.arizonapirg.org/AZ.asp?id2=23683. See also: http://www.serconline.org/payd/links.html, which links to a wide variety of PAYD studies and materials.

traveled, due to calmer driving style and a lower rate of speed law violation on high speed roadways)

- Convert to CO_2

Table H-8. Pay as you drive (PAYD) quantifications

Option No.	Policy Option	GHG Reductions ($MMtCO_2e$)			Net Present Value 2008–2020 (Million $)	Cost-Effectiveness ($/tCO_2e$)	Level of Support
		2012	2020	Total 2008–2020			
TLU-6	Pay-As-You-Drive (PAYD) Insurance	1.0	3.4	23.0	Large net savings		Unanimous consent.

PAYD = Pay-As-You-Drive; GHG = greenhouse gas; $MMtCO_2e$ = million metric tons of carbon dioxide equivalent; $ = dollars; $/tCO_2e$ = dollars per ton of carbon dioxide equivalent; TLU = Transportation and Land Use.

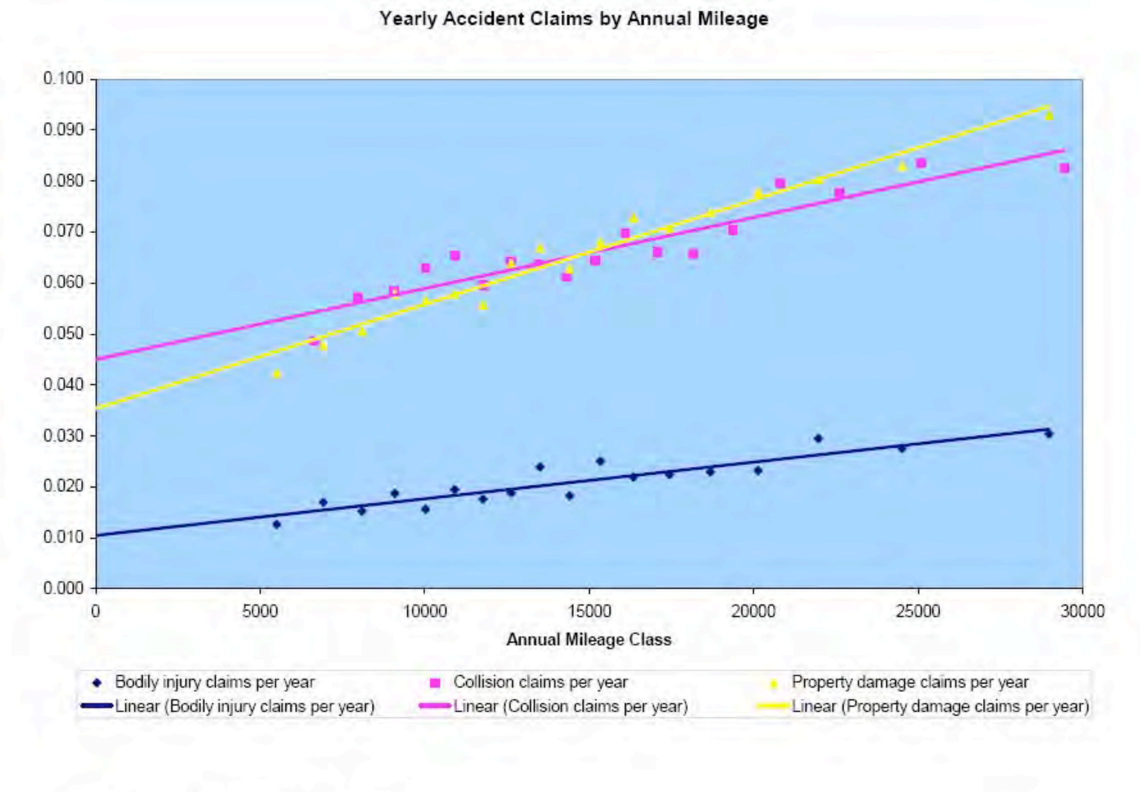
Net present value/cost-effectiveness:

The success of the Progressive Insurance earlier "Autograph" pilot in Texas, where the average household reportedly saved over $100/year on insurance through PAYD, suggests that there is an unmet demand for more choice in auto insurance. If PAYD improves and increases consumer choice, and allows insurance providers to more efficiently align risks and premiums, then economic efficiency will increase. Multiple studies have concluded that PAYD insurance pricing is likely to reduce driving, which in turn can be expected to reduce the number of motor vehicle crashes and related casualties. Progressive Insurance data shows a linear but not 1:1 relationship between miles driven and accident claims, as shown in Figure H-2 below. Thus, this reduces the amount of total claims, cutting insurance costs overall for consumers, as well as reducing health costs, traffic congestion, and air pollution. The net result is that PAYD can be expected to produce large savings for consumers and taxpayers, while reducing GHG emissions. Preliminary results from a forthcoming Brookings Institution study of PAYD suggest total annual benefits of $225/vehicle and an 8% overall traffic reduction.[26]

[26] J.E. Bordoff and P. Noel. In press. *Pay-as-you-drive auto insurance: a simple way to reduce driving-Related harms and increase equity,* Brookings Institution: Washington, DC. See also: http://www.brookings.edu/articles/2008/spring_car_insurance_bordoff.aspxraft study is available at http://www.brookings.edu/~/media/Files/rc/papers/2008/0417_payd_bordoff/0417_payd_bordoff.pdf.

A study by the California Economic and Technology Advancement Advisory Committee (ETAAC), titled "Technologies and Policies to Consider For Reducing Greenhouse Gas Emissions In California" (http://www.arb.ca.gov/cc/etaac/ETAACFinalReport2-11-08.pdf), evaluated various ways to reduce GHG emissions and gives strong support for mobility management strategies, such as PAYD vehicle insurance because it recognizes their co-benefits (e.g., congestion and accident reductions).

Figure H-2. Relationship between miles driven and accident claims



Source: Progressive (2005)

Key Assumptions: None cited.

Key Uncertainties

There are various options for introducing PAYD, use-based or per-mile insurance pricing. There are uncertainties about how different pricing and information mechanisms will affect behavior. Having a device on the dashboard that notifies the motorist in real time that it costs more per mile to drive at one time or another, or when traveling significantly over the speed limit, or when driving aggressively, would have a bigger impact in reducing GHG emissions than getting a policy rebate notice by mail at year end that is based on miles driven, even if the total charges in each case would be equivalent. Calm driving generates less fuel use and GHGs than aggressive driving with rapid accelerations and sharp braking, so a GHG-optimal PAYD policy might reward calm drivers with cost savings, as well as savings due to reducing driving. A PAYD policy that sets the incremental cost per mile of travel at a low level (for example, less than \$0.01/mile) will produce much less traffic and GHG reduction than a policy that more fully marginalizes the cost of insurance based on motor vehicle usage.

The simplest approach is to establish vehicle insurance premiums directly on the amount a vehicle is driven. Maryland could promote early action for GHG reductions through near-term encouragements or requirements for mileage-based pricing for PAYD insurance. Existing rating factors could be incorporated so vehicles with higher fees pay more per mile than those with lower fees. Such PAYD fees are easy to calculate: simply divide *existing* annual fees (or a large portion of them) by the average annual mileage of each vehicle class (typically about 12,000 annual miles). For example, a \$500 annual premium becomes \$0.042/mile, and a \$1,200 annual premium becomes $0.10/mile. The only significant new administrative cost would be the need to perform annual odometer audits, which would typically take a few minutes and cost less than $10 (most motorists would probably have audits performed by their broker or during scheduled maintenance, such as oil changes or emission inspections, minimizing the cost). Many transactions are already based on odometer readings, such as vehicle warranties, lease fees and used vehicle sales. Odometers are now highly tamper-resistant. Most types of fraud could be detected during annual audits and crash investigations. Odometer audits should provide data comparable in accuracy to that used in other common commercial transactions.

As noted above, several private insurance companies in other jurisdictions already base some portion of premiums on mileage, beyond the tiny amount that is customary, demonstrating that it can be attractive to consumers and financially successful. Most current PAYD programs require in-vehicle monitoring devices, allowing premiums based on time and—in cases where GPS is used—location. This can allow greater actuarial accuracy, but it increases administration costs, adding $50 to $100/vehicle-year. For some people this raises privacy concerns. In addition, Progressive Insurance holds patents on this type of pricing, so competitors would need to either pay royalties, or risk a patent infringement lawsuit.

There are growing efforts to move towards adoption of national distance-based road user charges as a replacement or complement to motor fuel taxes over the next 10–15 years.[27] This change would entail universal adoption of in-vehicle devices to monitor vehicle use, supporting universal PAYD insurance. The market will help determine whether all of the benefits of using more advanced technologies to monitor driving to implement PAYD are worth the costs and find wide societal acceptance. In the meantime, Maryland should take steps to advance universally available insurance with odometer-based pricing to secure much needed early action for GHG reductions.

Additional Benefits and Costs

Equity Impacts

PAYD insurance that fully shifts premiums to be based on the amount people drive will significantly improve equity in insurance pricing. As one recent report stated,

> “Current vehicle insurance pricing significantly overcharges motorists who drive their vehicles less than average each year, and undercharges those who drive more than average within each price class. Since lower-income motorists drive their vehicles significantly less on average than higher-income motorists, this is regressive. Distance-based insurance is fairer than current pricing because prices more accurately reflect insurance costs.
>
> “Distance-based pricing benefits lower-income drivers who otherwise might be unable to afford vehicle insurance, and who place a high value on the opportunity to save money by reducing vehicle mileage. It benefits lower income communities that currently have unaffordably high insurance rates…. Distance-based insurance would provide significant savings to workers during periods of unemployment, when they no longer need to commute.”[28]

A forthcoming Brookings Institution Hamilton Project analysis of PAYD insurance, by Jason E. Bordoff and Pascal J. Noel, includes an evaluation of PAYD benefits by income group. This

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[27] See, for example, reports of the U.S. National Surface Transportation Policy and Revenue Study Commission, January 2008, and the U.S. Surface Transportation Infrastructure Finance Commission, January 2008.

[28] Ridlington and Brown. 2006. op. cit.

preliminary analysis shows how average U.S. vehicle mileage increases as household income rises, based on 2001 National Household Travel Survey data, and the share of U.S. households likely to save money with PAYD by income.[29]

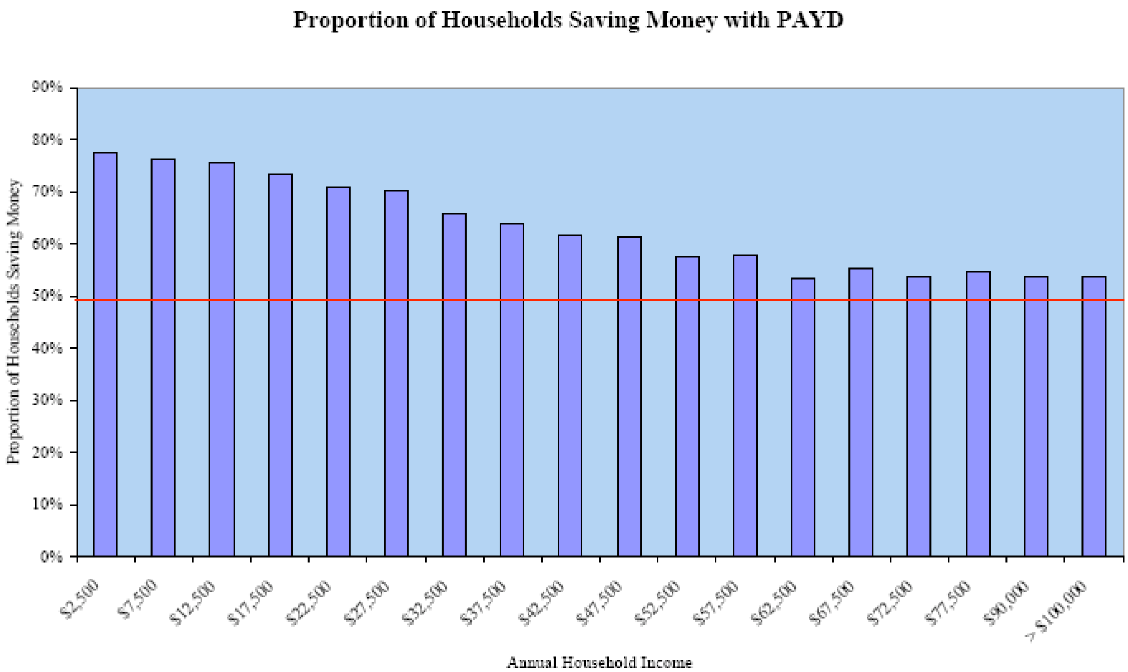
There exists a direct relationship between the miles driven and household income level as shown in Figure H-3.

Figure H-3. Relationship of miles driven and income

For some, PAYD will accrue notable savings as illustrated in Figure H-4.

[29] J.E. Bordoff and P. Noel. In press. *Pay-as-you-drive auto insurance: a simple way to reduce driving-related harms and increase equity, Brookings Institution:* Washington, DC.

Figure H-4. Can people save money through PAYD?

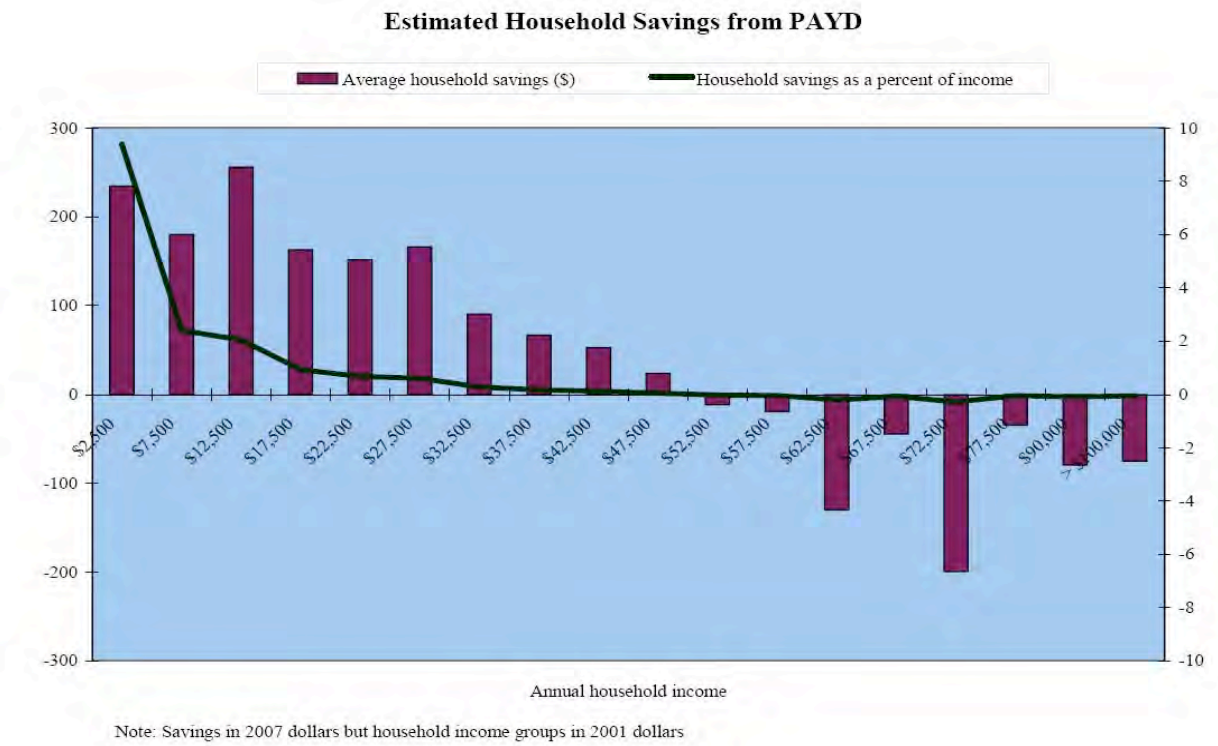


PAYD = Pay-As-You-Drive.

The forthcoming Brookings Institution study estimates savings from PAYD by income group. Almost two-thirds of households save money on their insurance under PAYD, with the average savings for this group amounting to $498, or 28% of their current policy costs. As Figure H-5 shows, lower income households particularly benefit, although a majority of drivers in every income group save money.[30]

[30] Bordoff and Noel, op.cit.

Figure H-5. Amount of savings from PAYD by household



Appropriately designed PAYD policies will be equitable and enable all drivers—in urban, suburban, and rural areas—to save money on their car insurance if they find ways to drive less than they now do by linking or sharing trips, choosing destinations closer at hand, or changing how they drive and travel. Lower income households devote a larger share of their income to transportation costs and are more price-sensitive than higher income households. The lower the household income, the greater the likely benefit from PAYD, although drivers from all income groups would benefit from the ability to control their insurance costs by strategically limiting their driving. Drivers living in rural areas, where people tend to drive more, will not face unfair impacts from PAYD policies, since under PAYD their premiums would be determined in relation to how many miles the average driver in their area travels and geography will remain a key risk factor.

Feasibility Issues

None cited.

Status of Group Approval

Approved.

Level of Group Support

Unanimous.

Barriers to Consensus

None.

TLU-8. Bike/Pedestrian Infrastructure

Policy Description

Improve, add, and promote sidewalks and bikeways to increase pedestrian and bicycle travel and reduce automobile use. Expansion of bike/pedestrian infrastructure would aid in decreasing the Maryland per capita VMT. A substantial body of research demonstrates that communities with traditional neighborhood design, connected pedestrian and bicycle networks, available transit and a rich mix of uses are strongly correlated with decreased automobile use.[31]

Policy Design

Goals:

Remove obstacles to providing and benefiting from improved bike/pedestrian infrastructure:

- Planning for local streets has often focused on the movement and storage of cars, while making walking and biking unsafe and unattractive through street design and management, neighborhood design, and parking policies.
- Local governments have lacked sufficient funding and incentives to maintain basic street infrastructure and invest in biking and walking.

Therefore, increase the bicycle- and walking-mode share of all trips in Maryland urbanized areas to 15% by 2020 by putting the following policies in place:

- Build on and implement infrastructure planning and designing tools that support and promote bicycle and pedestrian activity. Improve accommodations for bicycles on public transit.
- Adopt financial requirements or provide incentives that promote bicycle and pedestrian activities.
- Investing much more in this area.
- Improve data collection for nonmotorized travel.

Timing: To reach the 15% goal, will need to begin immediately.

Parties Involved: Local governments, transit agencies, Washington Area Bicyclist Association (WABA), Baltimore Bicycle Association, League of American Bicyclists (LAB), Rails-to-Trails Conservancy, other Maryland bicycling organizations, safety groups, Parent-Teacher Associations (PTAs), Safe Routes to Schools (SRTS) Coordinators, and traffic police.

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[31] L.D. Frank et al. 2006 (Winter). Many pathways from land use to health: associations between neighborhood walkability and active transportation, body mass index, and air quality. *Journal of the American Planning Association* 72(1). "We found a 5% increase in walkability to be associated with a per capita 32.1% increase in time spent in physically active travel, a 0.23-point reduction in body mass index, 6.5% fewer vehicle miles traveled, 5.6% fewer grams of oxides of nitrogen (NO_x) emitted, and 5.5% fewer grams of volatile organic compounds (VOCs) emitted."

See also the Land Use, Transportation, Air Quality, and Health (LUTAQH) Study, among others. Discussed by L. Aurbach in "Connectivity Part 4: Neighborhood Walking," available at: http://pedshed.net/?p=71

Implementation Mechanisms

Following details are recommended for the policies mentioned above:

- Introduce infrastructure planning and designing tools and concepts, such as
  - A statewide "Complete Streets" policy:
    - Complete street policies require that new streets, or streets undergoing major maintenance, be designed to accommodate all users; and
    - Local governments could be required to adopt Complete Street policies for their spending, or provides substantial incentives to localities to do so, e.g., making state transportation grants to localities contingent on project consistency with Complete Street policies.
  - A rewrite of the Highway Design Manual to require all new engineering and construction to accommodate safe, convenient movement of bicycles and pedestrians along all non-limited corridors, as well as across corridors where these act as barriers, unless exceptional circumstances exist.
  - Local land-use policies could be mandated to include requirements for shower and bike storage facilities in new buildings, and design requirements to promote a pedestrian friendly environment.
  - Add bike storage at transit stations and employers. Provide grants and incentives to develop bike stations at major transit and activity centers to ensure secure overnight bicycle storage, bike rentals, and related services.
- Financial requirements or incentives that promote bicycle and pedestrian activities include:
  - Increased funding available for bicycle and pedestrian projects.
    - Provide grants to localities to develop plans and policies to encourage biking and walking, including public education, safety, engineering, and revisions to local land-use policies.
    - Provide grants to local governments to identify and study the gaps in their bicycle and pedestrian infrastructure and determine how these gaps can be best filled by street-related improvements as well as those associated with other public right-of-ways (e.g., parks, inter-street links, and specialized structures).
  - Fund and implement low-cost safety solutions that improve conditions for bicycling and walking in maintenance projects like paving projects.
  - Provide local governments with new taxing authority and more flexibility with gas tax revenues to finance local improvements.
    - Initiate a pilot program with funding and technical assistance under which local governments and neighborhoods can readily form neighborhood improvement districts to develop public-private partnerships that manage and price on-street parking by time-of-day to ensure a portion of spaces are available even during times of peak demand, with surplus parking revenues available for streetscaping, pedestrian and bicycle infrastructure and services, and neighborhood improvement districts.
    - Over time, increase the share of state transportation funding made available to local governments for pedestrian and bicycle improvements to more closely match the

share of travel in the state of Maryland that involves a pedestrian or bicycle trip for some portion of the journey and the share of traffic accidents involving pedestrians or cyclists.

- The goal would be provide sufficient funding for localities to build out their pedestrian and bicycle networks, invest in inviting streetscapes to accompany new development, and retrofit existing streets to prioritize transit, biking and walking.
- Similarly, local transit agencies should be granted additional voter-approved revenue sources.

Related Policies/Programs in Place

The proposed policy would build on the model of Clean Air Act conformity, adapting that model to growth in VMT and CO_2. That model takes one piece of a state-level challenge—future growth—and gives it to local jurisdictions closest to the source of the growth. The model uses the locals' structure to respond, while building on incentives and technology adopted by the state.[32]

Type(s) of GHG Reductions

Primarily CO_2 and carbon black.

Estimated GHG Reductions and Net Costs or Cost Savings

Key Assumptions: This is financed through TLU-9 (Incentives, Pricing, and Resource Measures) and implemented in coordination with TLU-3 (Transit). GHG reductions are not quantified independently.

The GHG emission reductions from the replacement of a significant share of short car trips with pedestrian and bicycle trips will be significant.

- National Transportation Survey Data (1990) demonstrates that more than half of commute trips, and three out of four shopping trips, are under 5 miles in length; ideal for bicycling. Additionally, 40% of all trips are less than 2 miles.
- Past national polls have found that 17% to 20% of adults say they would sometimes bike to work if safe routes and workplace parking and changing facilities were provided[33]. A comprehensive review of nonmotorized travel data indicates, "considerable latent demand for bicycling and walking will be released if infrastructural impediments to these modes are removed or mitigated."[34]

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[32] For example, see Environmental Defense, "Incorporating Environmental Performance into Transportation Projects," memo to TLU TWG, January 30, 2008.

[33] Harris Poll data published by *Bicycling* magazine, April 1991 and by Rodale Press, 1992.

[34] University of North Carolina Highway Safety Research Center (HSRC). 1994 (Oct.). A compendium of available bicycle and pedestrian trip generation data in the United States (for the FHWA).

- Overall, creating bicycle/pedestrian-friendly communities can result in between a 5% to 15% reduction in overall VMT in a community[35]. These figures can be even higher in close proximity to bike/pedestrian facilities with local reductions of 20% to 30%.[36]

Key Uncertainties

None cited.

Additional Benefits and Costs

Substantial health benefits.

Feasibility Issues

None cited.

Status of Group Approval

Approved.

Level of Group Support

Unanimous.

Barriers to Consensus

None.

[35] T. Litman, T. 2007. Win-win emission reduction strategies: smart transportation strategies can achieve emission reduction targets and provide other important economic, social, and environmental benefits. Prepared for the Victoria Transport Policy Institute (VTPI). Available at: http://www.vtpi.org/wwclimate.pdf

[36] S, Winkelman. 2007 (Feb.). Linking green-TEA and climate policy. Presentation prepared for the Center for Clean Air Policy (CCAP). Available at: http://www.ccap.org/transportation/documents/LinkingGreen-TEAandClimate-PolicyCCAP3-12-07.pdf.

TLU-9. Incentives, Pricing, and Resource Measures

Policy Description

Pricing and incentives provide information that helps allocate scarce resources and encourage wise stewardship when consumers make choices. Current transportation pricing and incentives in Maryland often encourage over-consumption of driving by hiding true environmental and social costs from travelers. Unless widespread perverse pricing incentives are modified, efforts to reduce GHG emissions through smart growth incentives and transit investments will fail.

Roadway tolling can help manage SOV use and provide revenue for alternative modes, but if tolls are used just to build new lanes or roads this will increase GHG emissions. Tolls that vary by time-of-day with congestion levels can reduce congestion and ensure efficient use of roads, preventing the loss of capacity that routinely occurs in stop-and-go conditions. Mileage and emission-based road user fees also help manage traffic and GHG emissions and finance transportation. Experience from around the world shows political acceptance of pricing existing roads is dependent on whether this is done in a way that significantly cuts congestion and helps ensure attractive alternatives to driving in the affected area. Thus, it makes sense to bundle implementation of pricing measures with TLU-3 (transit improvements) and TLU-8 (walking and cycling improvements).

Employer commute incentives have a profound impact on travel behavior. Offering free workplace parking is a major inducement for commuting by car. Commuter Choice Programs encourage employees to use other travel options by supporting telecommuting, reducing the cost of transit commuting through subsidies or pre-tax transit fare programs, offering cash-in-lieu-of-parking to encourage ridesharing, biking, walking, or transit use, and guaranteed ride-home service in order to reduce automobile dependence. Telecommuting promotion may include the development and support of neighborhood telecommuting centers that offer office-type services in locations close to commuters' residences. Government spending to encourage commuter choice can stimulate a large private-sector match ($17 of private incentives/dollar of public incentive, according to one source).

Automobile use is strongly influenced by the location, supply, and pricing of parking. Local governments can encourage reduction in automobile use by eliminating minimum parking supply requirements, establishing parking supply caps, encouraging higher parking prices, developing parking management districts, and other mechanisms. Parking ratios for the maximum number of spaces allowed can be set based on an area's level of transit service. Smart parking identification systems can help inform drivers of parking availability and reduce excessive circling and searching.

This option responds to these dynamics by implementing a set of Incentives, Pricing, and Resource Measures, that would together use market signals to help Maryland agencies and citizens manage travel using better information about costs and benefits, and use a restructured transportation pricing system to fund investments in that system to accept growth and support quality of life without increasing GHG emissions.

Policy Design

Goals:

The goal for Maryland transportation pricing should be to foster efficient use of existing transportation infrastructure and services to support a vibrant economy with expanded, attractive travel choices for all, with equitable access to jobs, affordable housing, and other opportunities.

Pricing incentive strategies should be considered and integrated into transportation planning, project review and development, corridor management and transportation system operations at the state, regional, and local level across Maryland. Major capital investments for new capacity should be undertaken only after considering how pricing measures might be used to improve the performance of related infrastructure and mobility services.

By 2020, automated time-of-day road pricing should be coming into more widespread use in metropolitan areas to significantly reduce traffic congestion delays that threaten economic competitiveness and to reduce GHG pollution to meet environmental goals. Such systems should be implemented in a way that ensures improved travel choices for low and moderate income travelers, providing targeted user-side subsidies as needed to ensure equitable, attractive opportunities for access to jobs and public facilities all across Maryland. Pricing strategies should be designed to enhance low-carbon mobility systems, such as walking, cycling, and public transportation, while ensuring high efficiency, high-speed mobility is available at all times in travel principal corridors for high value trips and freight shipments.

By 2020, workplace commuter benefit discrimination against commuters who walk, bike, ride transit, or rideshare should be eliminated in Maryland, and the state should be seen as a national leader in providing workplaces such means of travel encouraged through smart commuter incentives.

Maryland should establish incremental carbon-based fees whose revenue would fund transportation investments and operations that reduce GHG emissions. Funds would be available to be spent on any carbon-reducing transportation measure. The GHG performance of the proposed transportation investments would be closely evaluated prior to funding, and closely tracked afterwards with performance-based contracts ensuring timely GHG reductions. GHG emission reductions will be greater if regional implementation can be coordinated. Such fees could be implemented beginning in the short run through a carbon fuel tax. The MWG does not recommend a specific amount for such a carbon fuel tax pending much more detailed analysis. For the purposes of illustrating the kinds of GHG reductions and revenue that such a carbon fuel tax might raise, the following general empirics were taken into account:

- Small amounts (up to $0.15) can have some demand impact, but can be more appropriately seen as a way to fund transportation related policies than to reduce consumption and emissions directly; and
- Larger amounts can have a more meaningful direct impact on consumption and emissions.

The MWG analyzed the potential impact of a carbon fuel tax starting in 2011 at $0.15/gal, and rising smoothly to the equivalent of $1/gal (real$) in 2020.

In the slightly longer run, carbon-based fees can and should be assessed through a more sophisticated set of instruments that help the state and its citizens respond to a broader set of needs than just carbon. For example, emission-based mileage charges can be used not only to reflect carbon emissions, but also manage congestion and road damages. The technology to implement these kinds fees is in commercial use in several places around the world. Germany, for example, currently uses such charges to raise approximately $3 billion a year from trucks.

In this policy option, revenue from these fees would fund primarily transportation-related investment and operations; a variation could use some revenue to reduce other taxes and fees.

Timing: *2009* Legislative Session for Commute Incentives and Reforms in how pricing and incentives are considered in planning (items 1, 2, and 3 in "Implementation Mechanisms" below), and 2011 Legislative Session for the revenue items (item 4).

Parties Involved: Automobile users, state departments of commerce, transportation, revenue, finance, and freight transportation sector.

Implementation Mechanisms

Commute incentives. Immediate steps should be taken to build on Maryland's efforts at shifting employer commute incentives by strengthening marketing, incentives, and requirements for employers, schools, and universities to reconsider commuter and student travel benefits that discriminate against those who walk, bike, take public transportation, carpool, or telework, and to adopt new incentives that instead favor these alternatives to solo car travel. The state should expand its promotion to employers and employees of the Maryland Commuter Choice Tax Credit, which offers up to $50/month tax credit to Maryland employers who offer cash-in-lieu-of-parking or transit benefits to employees. The credit is even available to nonprofit corporations as a deduction from state withholding taxes. The state should take expeditious steps to ensure all state agencies, state contractors, and as permissible and feasible, state grantees, such as universities and schools, offer transit benefits and, as feasible, cash-in-lieu-of-parking benefits to their employees. The state should encourage testing of parking impact fees in transit-served metropolitan communities that would be waived for employers who offer cash-in-lieu-of-parking and transit benefits, with a de minimis exemption for small businesses.

Low-GHG transportation investment fund. The revenue generated from any of the pricing or fee initiatives in this policy (e.g., carbon-fuel, carbon-road) should be invested in transportation projects (e.g., capital and operational) that improve choice and reduce GHG emissions. To illustrate how such an example would work

- To implement the multimodal transit elements of this policy,
    - State, regional, and local transit plans are to be developed, as well as the transit promotion programs and other related programs such as improved bike/pedestrian access to stations and BRT.
    - Funding gaps that exist to implement these plans should be assessed.
    - Proportion of the gap that would be covered by the gas tax levied should be determined.
    - The Governor should create an interagency group to identify ways to reduce GHGs and develop resource allocation strategy to:

  - Recognize different regional needs (especially rural versus metropolitan);
  - Establish cost-effectiveness/emission-reduction criteria for determining how tax revenue will be spent; and
  - Establish a mechanism to ensure that revenue can only be spent for low-carbon transportation options and not for other state purposes.
- To implement the non-transit transit elements of this policy, state, regional, and local needs and opportunities to reduce GHG emissions from transportation through non-transit investments, tax abatements, and incentives for infill and redevelopment are to be developed. The state should lead, working together with regional and local jurisdictions.

Travel Smart marketing. The state should fund and implement a form of "Travel Smart" individualized transit marketing. This kind of marketing has shown power in Portland, Oregon, Perth, Australia, and various communities in Europe as a way to reduce car use through better information. It is included in this policy option rather than in TLU-3 Transit because it helps people understand their costs, benefits, and incentives related to transit and non-SOV travel. It can be seen as an extension of Commuter Connections, where Travel Smart deals not just with work-related trips, but all travel.[37]

Pricing and incentives in planning, project development, and operations. The MDOT Secretary should adopt policies to foster the routine consideration of pricing incentives in state and regional transportation planning, project development, and operations. The Governor should convene a Transportation Pricing and Revenue Study Commission to review how new approaches to pricing and transportation finance might help the state address multiple simultaneous challenges: climate change, mobility system financing, congestion, economic competitiveness, housing affordability, and growing income inequality. The Governor, legislature, and state officials should work with appropriate stakeholders to further refine policy options and strategies for planning, testing, and implementation, including those listed below.

The most effective management of GHG emissions in Maryland's transportation sector would result from the establishment of the following pricing measures throughout the state by 2020:

- GHG emission-based road user fees statewide to complement or replace motor fuel taxes, with congestion pricing as a local option in metropolitan areas, with revenues used to fund transportation improvements and systems operations meeting state goals.
- Time-of-day emission-based cordon pricing in appropriate central areas as a local option to finance improved public transportation,
- Parking pricing policies that ensure effective use of urban street space for the highest and best uses, giving greater priority to low-carbon modes of transportation (e.g., walking, cycling, and public transportation), while ensuring efficient, effective, and attractive mobility

[37] See R. Salzman. 2008 (Apr.) TravelSmart: a marketing program empowers citizens to be a part of the solution in improving the environment. *MassTransitMag.com.* Available at: http://www.masstransitmag.com/print/Mass-Transit/TravelSmart/1$5825 Excerpt: "People want to be part of the solution, they just don't know how," explains Werner Brög, the founder of the concept. "Across three continents, we've found that people always underestimate the time and cost of using the car and overestimate the time and cost of using environmentally friendly modes. "Our philosophy is that we never tell them what to do. We empower people to do what they can do by addressing those misperceptions."

choices for all residents and businesses, including those dependent on private motor vehicles, as discussed under TLU-8. Provision of off-street parking should be regulated and managed in all urban, suburban, town, and village centers of development, with appropriate impact fees, taxes, incentives and regulations to ensure sound user pricing and provision of parking spaces appropriate for smart growth development and GHG management.

Implementing such approaches will require substantial efforts (in addition to those now underway) to identify and evaluate options, plan and develop pilot tests, and cultivate public understanding and acceptance of new approaches to mobility system management and financing. The experience and approach of other states (e.g., Washington, California, New York), and other affluent urbanizing coastal regions (e.g. the Netherlands, Sweden, and the United Kingdom), in this arena are relevant to Maryland and deserve close attention from the state's policy makers.

Initial pilot tests of road pricing now moving forward in several corridors in Maryland will involve use of toll managed lanes. However, these must be carefully considered for their implications for long-term GHG growth, as global experience and research, as well as recent planning studies by the Metropolitan Washington Council of Governments (MWCOG) Transportation Planning Board, clearly show that adding significant toll-managed lane capacity will increase, not decrease VMT and related GHG emissions, and that the high cost of adding road capacity typically leaves little or no toll revenues to pay for improved public transportation. Future planning should consider how existing road capacity might be managed for higher productivity through congestion pricing and transit improvements to minimize the demands for addition of costly high-speed road capacity.

Related Policies/Programs in Place

The 2009 Maryland Transportation Plan (MTP) is now under development. The last MTP was issued in 2004. State transportation funding plans are outlined in the Consolidated Transportation Program (CTP), the department's 6-year capital program outlining transportation projects around the state.[38] Speaking broadly, the current commitments would not attain the goals proposed here.

The MDOT, in cooperation with the MPOs, MDE, and local government bodies, has the following in place with regards to expanding commuter choice and offering of commuter benefits in the state: GRH for transit users. GRH is in place in the Washington region and portions of the Baltimore region.

Ridesharing: MDOT works with the counties and MWCOG to help facilitate ride matching

Commuter Choice: Under the Maryland Commuter Benefits Act of 2000, employers may take a 50% tax credit on sponsored commuting costs and cash-in-lieu-of-parking benefits up to a maximum credit of $50/employee per month applied toward the state income tax, the financial institution franchise tax, or the insurance premium tax. Maryland nonprofit organizations can take the credit as a deduction from state withholding taxes. Commuting costs are applicable to transit passes, vouchers, tokens or other valid non-cash instruments that are accepted as payment by public and private transportation services, with the exception of private taxi service. Initially efforts to promote this tax credit to employers appear to have fallen off, and use of the credit is not widespread due to very low awareness of the benefit among employers.

[38] http://www.e-mdot.com/Planning/Plans%20Programs%20Reports/Programs/Index.html

Type(s) of GHG Reductions

Primarily CO_2 and black carbon.

Estimated GHG Reductions and Net Costs or Cost Savings

The recommendations under this policy option cover policies that can be technologically implemented immediately (fuel tax and Commuter Choice) and those that would take longer to implement in Maryland. Only the impacts of the first kind are quantified here: carbon fuel tax and Commuter Choice programs.

Table H-9. TLU-9 Quantifications estimates

Option No.	Policy Option	GHG Reductions ($MMtCO_2e$)			Net Present Value 2008–2020 (Million $)	Cost-Effective-ness ($/tCO$_2$e)	Level of Support
		2012	2020	Total 2008–2020			
TLU-9	Incentives, Pricing, and Resource Measures	2.6	3.7	32.8	–$1	–$1	Unanimous

TLU = Transportation and Land Use; GHG = greenhouse gas; $MMtCO_2e$ = million metric tons per carbon dioxide equivalent; $ = dollars; $/tCO$_2$e = dollars per ton of carbon dioxide equivalent.

Data Sources:

For Commuter Choice

- ICF Consulting. 2004 (Nov.). Commuter connections strategic review, final report. Prepared for MDOT, Office of Planning and Capital Programming.
- ICF Consulting. 2005. Analyzing the effectiveness of commuter benefits programs. Transit cooperative research program report 107.[39]
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For Carbon Fuel Tax

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[39] http://onlinepubs.trb.org/onlinepubs/tcrp/tcrp_rpt_107.pdf

[40] http://onlinepubs.trb.org/onlinepubs/tcrp/tcrp_rpt_87.pdf.

- ICF Consulting. 2004 (Nov.). Commuter connections strategic review, final report. Prepared for MDOT, Office of Planning and Capital Programming.

Quantification Methods:

Commuter Choice programs

- Increased funding for existing DC-area Commuter Connections: $12 million.
- Increased funding for existing and new Commuter Connections-type programs in Baltimore, Frederick, and throughout the state: $20 million.

Impact: Commuter Connections currently reduces 1,774,670 VMT/day (461,414,200 VMT/year), for $5 million/year.

Maryland VMT in 2005 was 51,430 million, thus Commuter Connections reduced statewide VMT by 0.89%. Moving from $5 million/year to $32 million/year on Commuter Connections-type programs should reduce VMT by ($32/$5 = 6.4 × 0.0089) = 5.7% (2,953,050,880 VMT)

Carbon fuel tax

The forecast effect of this policy turns on two calculations: (1) the elasticity of demand for fuel with respect to price, and (2) the responsiveness of VMT to investments in its reduction.

If a carbon fuel tax is implemented, it will have benefits in terms of revenues raised for the state to fund GHG mitigation measures, as well as GHG reduction from increased fuel costs.

In response to recent data showing a low gasoline elasticity of demand, we use an elasticity of 0.1. The GHG reductions reported in the table are due to the demand response only. The elasticity of demand for gasoline is a subject of ongoing quantification by economists, and as the U.S. enters a period of historically unprecedented prices for gasoline, there is not a consensus on the likely consumer response.[41] The elasticity of demand of 0.1 used is historically low, which is to say, for these purposes, conservative; it is at the low end of the range, and so possibly underestimates the carbon reductions gained from a carbon fuel tax.

The revenue from the tax is invested in projects, services, and incentives that reduce VMT. Those reductions are quantified in the category in which the revenue is spent. Thus, a carbon fuel tax that increased smoothly from $0.15/gal (for conventional gasoline) in 2008 to $2.00/gal in 2020 would reduce demand directly by about 0.8 $MMtCO_2e$ in 2012. It would also rise to (at $0.77/gal) about $2.8 billion/year in 2012. For this analysis, we assume that the carbon fuel tax rises from $0.15 to $1 in 2020, and that the other half of the $2.8 billion/year is raised through some combination of other carbon- and road-charges.

Benefits

The most cost-effective VMT-reducing Commuter Choice programs in the country are in the District of Columbia region, reducing VMT at approximately $0.01–$0.02/VMT.[42] Such a

[41] For example, recent statistics from California suggest a roughly –0.2 elasticity. M. Glover. 2008. State's drivers reduce gas use. *Sacramento Bee* 1 May 1. Available at: http://www.sacbee.com/wheels/story/903743.html

[42] ICF Consulting. 2004 (Nov.). Commuter connections strategic review, final report. Prepared for MDOT, Office of Planning and Capital Programming.

program can effectively invest much more than its current budget, but almost certainly not $2.8 billion. The rest would go into funding transit and pedestrian, bicycle, intermodal freight, traffic management, and demand management measures, whose impacts are quantified largely in TLU-3.

The TWG needs to advise on an investment split between commuter benefits programs and other programs and measures.

For this round of analysis, we assume the following use of the $2.8 billion in 2012:

- Commuter Choice programs:
  - Increased funding for existing D.C.-area Commuter Connections: $12 million
  - Increased funding for existing and new Commuter Connections-type programs (including parking cash out) in Baltimore, Frederick, and throughout the state: $20 million

  Impact: Commuter Connections currently reduces 1,774,670 VMT/day (461,414,200 VMT/year), for $5 million/year.

  Maryland VMT in 2005 was 51,430 million, so Commuter Connections reduced statewide VMT by approximately 1%. Moving from $5 million/year to $32 million/year on Commuter Connections-type programs should reduce VMT by ($32/$5 = 6.4 * 0.0089) = 5.7%

- Transit and non-SOV travel investments: $2.8 billion – $32 million = $2,768,000,000.

The MWG direction on how to analyze spending this revenue: “Focus on the options most likely to reduce GHG emissions.” For this round of analysis, we proceed as follows:

2007 Maryland Department of Transportation (MDOT) capital expenditures

Maryland Transit Administration (MTA)	$1.5 billion
Washington Metropolitan Area Transit Authority (WMATA)	$1.1 billion
2007 MDOT operating expenditures	
MTA	$0.5 billion
WMATA	$0.2 billion
Total	**$3.3 billion per year**

MDOT = Maryland Department of Transportation; MTA = Maryland Transit Administration; WMATA = Washington Metropolitan Area Transit Authority.

An additional $2.78 billion/year would be an 84% increase in total transit expenditures.

Total transit ridership in Maryland in 2006 was 252,773,000 trips. An 84% increase in trips would produce an additional 212,329,000 trips. This is very close to a doubling in transit ridership. Thus:

We report here in TLU-9 only those reductions from the direct impact of the proposed carbon tax via fuel.

We report:

- In TLU-3 the reductions from investments in transit, since the revenue raised in TLU-9 would be almost exactly the amount needed to double transit expenditures, and thus the double ridership goal in TLU-3; and
- Here in TLU-9 the reductions from investments in commuter connections programs.

Costs

Generally, tax revenue is considered a transfer payment, and is not analyzed as a "cost." Whether a carbon fuel tax is the most efficient (least distortionary) way to raise revenue with which to make the above investments is beyond the scope of this analysis. We observe that the $2.8 billion is 1.09% of Maryland's Gross State Product (GSP).[43]

Another way to use the revenue would be to rebate it or "recycle" it, such as through a reduction in the income tax, a reduction in employer payroll taxes, or abatement of taxes on urban infill TOD. Such a use would shift taxations from "goods" (e.g., income, jobs, smart growth) to "bads" (e.g., GHG emissions). The literature on revenue recycling of carbon taxes is too extensive to summarize here. There is widespread agreement that revenue recycling reduces the costs of any carbon tax; the extent to which it does so has less agreement, and is subject to the specifics of the case.

Key Assumptions:

GHG impacts

The assumptions are given above. These kinds of increases are possible, considering more than half of the surveys reported an increase in transit riders between 10% and 40%, and nearly one-quarter reported increases of more than 60%. Furthermore, two surveys—one in San Jose in 1997 and one in Atlanta in 2003—suggest that transit ridership more than doubled after a transit benefits program was implemented.[44]

Costs

The costs of providing commuter benefits at the work place vary widely. Contributing to employee commuter benefits financially produces the largest mode shifts. Simply allowing an employee to participate in a pre-tax transit pass deduction actually saves the employer money, and generally produces almost as much mode shift. Employers then save money on parking, on turnover, and on employee stress.

In a national survey of employers about why they did or did not offer commuter benefits, the main concern was not cost, but the perceived hassle of adding an additional benefit. This, we show as the main cost the state's investment in promoting Commuter Connections.

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[43] Federal Reserve Bank of Richmond (FRB), http://www.richmondfed.org/research/regional_conditions/regional_profiles/maryland/output/gross_state_product.cfm

[44] ICF Consulting. Analyzing the effects of commuter benefits programs, Internet conference (live broadcast April 7, 2005) featuring ICF International's Michael Grant, lead author of the Transit Cooperative Research Program (TCRP) Report 87, *"Strategies for Increasing the Effectiveness of Commuter Benefits Programs."*

At the IRS mileage rate of $0.505/mile, cost savings to commuters would total:

2,953,050,880	VMT
× $0.505	
$1,491,290,694	
– $32,000,000	Investment in Commuter Connections
$1,459,290,694	

In order for there to be negative benefits, costs per employee statewide would have to exceed:

$1,459,290,694 savings per 2,530,000 employees = $576 per year

With an MTA pass at $64 per month/$768 per year, it seems highly unlikely that all savings from reduced driving costs would be used up by additional transit fare costs. A substantial portion of the target population would be in the Washington DC suburbs, where transit costs are higher, but these would be balanced by those in the many parts of Maryland with far lower costs.

For a broader discussion of the difficulty of quantifying these benefits in terms of $ per ton, please see TLU-3.

More generally, for this round of analysis, it is assumed that

- The revenue raised in this Policy Option is spent as outlined above, and
- Notwithstanding the proposed fund's ability to invest in *non-transit* GHG-reducing actions, the assumption is that the two most effective uses of the funds are:
  - To help people use transit and non-SOV options that are in place, which is the role of Commuter Connections and related programs targeting non-commute trips; and
  - To expand the transit and related options and incentives that those programs need.

  Clearly the two are also linked; the one is most effective with the other.

Key Uncertainties

Response to carbon fuel tax, any other charges.

How the state will choose to invest the revenue.

Additional Benefits and Costs

None cited.

Feasibility Issues

None cited.

Status of Group Approval

Approved.

Level of Group Support

Unanimous.

Barriers to Consensus

None.

TLU-10. Transportation Technologies

Policy Description

Reduce GHG emissions from on-road vehicles and off-road engine vehicles (including marine, rail and other off-road engine and vehicles, such as construction equipment) through deploying technology designed to cut GHG emission rates per unit of travel activity.

Emissions reductions on on-road vehicles are expected from

- The implementation of the committed-to Maryland Clean Car Program and new policies to spur development and use of Plug-in Hybrids; and
- A combination of intelligent vehicle infrastructure, driver education (for fuel efficient traffic operation), and smart traffic operations and management designed to simultaneously reduce congestion, curb traffic growth, and expand travel choices.

Transportation management systems improve vehicle flow on the roadway system, which can reduce fuel use and GHG emissions. Coordinated operation of the regional transportation network can improve system efficiency, reliability, and safety. Tools to reduce traffic congestion include high-occupancy vehicle (HOV) lanes, roundabouts at intersections, synchronized signals, incident management, variable message signs, and other forms of ITS, such as real-time traffic information and dynamic road-way pricing.

Policy Design

Goals:

To reduce emissions from on-road engines/vehicles by an additional 7.5% by 2020 from current adopted baseline policies (particularly including the Maryland Clean Car Bill) through more efficient technologies and operations. Reduce emissions from off-road transportation sources through use of more efficient technologies and operations by 15% by 2020.

Policies to be implemented that relate to off-road engines/vehicles include:

- Provide incentives to increase purchases of fuel-efficient or low GHG vehicles,
- Increase the use of alternate fuels or low sulfur diesel to reduce GHG emissions,
- Reduce idling time in locomotive and construction equipment,
- Initiate marketing and education campaigns to operators of off-road vehicles,
- Adopt “Green Port Strategy” for Baltimore area port facilities, and
- Adopt state contracting and fleet standards for low GHG equipment procurements.

TMS policies to be developed, refined, and implemented include:

- Active traffic management (ATM);
- Traffic management center(s);

- Traffic signal synchronization;
- Managed lanes, dynamic roadway, and full corridor pricing;
- Smart parking systems; and
- Bus signal priority.

Plug-in hybrids and other high-fuel economy vehicles should be encouraged through further incentives such as feebate programs. If California adopts additional regulations to require reduced GHG intensity in motor vehicles, Maryland should follow its lead in light of federal preemption requirements.

Timing: To be determined.

Parties Involved: To be determined.

Other: Not applicable (N/A).

Implementation Mechanisms

Details for implementing policies include

- Providing incentives to increase purchases of fuel-efficient or low-GHG vehicles.
  - Examples of vehicles targeted by this program include pure electric, hybrid, plug-in hybrid, and other AFV.
  - Examples of incentives include
    - Fees on relatively high emissions/lower fuel economy vehicles (that is, higher vehicle registration fees can be charged for vehicles that have lower fuel economy, or vehicles that use alternative fuels could be charged a lower vehicle registration fee. Vehicle licensing fees could be based on vehicle weight, with use of a dollar per vehicle-ton multiplier instead of the present broad categories of vehicle weight.
    - Rebates or tax credits on low emissions/higher fuel economy vehicles.
    - Implement a sliding scale tax that would allow purchasers of low GHG emitting vehicles to earn a rebate on their vehicle registration or sales tax of up to X%, and purchasers of high GHG emitting vehicles to be assessed a vehicle registration or additional sales tax of up to X%. The sliding scale could be designed to be revenue-neutral in such a way that rebates would be offset by fees assessed.
- Increase the use of alternate fuels or low-sulfur diesel to reduce GHG emissions. By increasing the availability and usage of alternative fuels (low-carbon fuel) and low-sulfur diesel for off-road vehicles, as well as recreational marine usage, there could be a significant reduction in GHG emissions.
- Reduce idling time in locomotive and construction equipment.
  - Consider increasing measures to reduce locomotive idling, including "auxiliary engines" to help maintain power, as well as "plug in" power receptacles in the proposed train storage yards.

- For equipment in construction contracts, there would be clauses that would restrict idling time in construction equipment.

- Initiate marketing and education campaigns to operators of off-road vehicles.
  - Providing the operators of off-road vehicles with better operations information and education can lead to a gain in fuel efficiency.
  - Operators also need to be aware of maintenance issues that cause an increase in pollution and vehicle operating cost. By ensuring vehicles are well maintained, fuel efficiency and emissions benefits can be achieved.
- Adopt "Green Port Strategy" for Baltimore area port facilities.
  - Introduce less polluting, more energy-efficient technologies for vessel dwelling and for land-side cargo handling equipment as part of strategy.
  - Include providing "shore power" at the port sites, where applicable and feasible for shipping vessels.
  - Replace diesel cranes at the Port; consider electrifying, or other methods to reduce GHG emissions, if feasible.

TMS Policy Options for Implementation

- **ATM:** The real time variable-control of speed, lane movement, and traveler information within a corridor and can improve traffic flow in the corridors where it is applied. The following is a list of technologies that are currently available. The implementation of TMS should not be limited to these examples, especially if other technological options are developed, and prove to more effective in reducing emissions than those listed below.
  - *Speed Harmonization/Queue Warning/Lane Control*—the ability to smooth traffic flows and speeds as vehicles approach congested areas and reduce the speed of vehicles as they approach queues. In Europe, this strategy has been shown to reduce primary and secondary accidents, reducing non-recurrent congestion. It has also been found to reduce congestion, queuing, and improve throughput. Speed control allows the highway to continue operating nearer to its highest throughput capacity as volumes increase. Specific performance measure is "increase operating speed for congested areas." Anticipated investment level to achieve it is medium.
  - *Traveler Information and Dynamic Rerouting*—providing Traveler Information opportunities including travel times and the availability of alternative routes around incidents and congested areas. Dynamic rerouting uses modified destination guide-signs and other traveler information methods to assist drivers through alternative routes. Specific performance measure is "reduction of delay" (time) from one destination to another. Other measures may include how much time it takes to change signals across various jurisdictions or alter signal timing dynamically for city streets. Anticipated investment level to achieve it is medium.

  Overall, benefits of ATM are reduced overall delay, reduced idling, and fewer secondary accidents that will also reduce delay and idling. Again, anticipated investment level to achieve it is medium.

- **Traffic Management Centers:** Provides centralized data collection, analysis, and real-time management of the transportation system. System management decisions are based on in-road detectors, video monitoring, trend analysis, and incident detection.
  - Specific performance measures are how quickly problems are identified and responded to and restored to normal, “reduced idling time,” and “reduction of secondary accidents.”
- **Traffic Signal Synchronization:** The timing and operations of the traffic signal operations are synchronized to provide an efficient flow or prioritization of traffic, increasing the efficient operations of the corridor and reducing unwarranted idling at intersections. The system can also provide priority for transit and emergency vehicles.
  - Specific performance is “reliability.” Anticipated investment level to achieve is fairly low, though development of concurrent local jurisdiction support and coordination may raise the cost to medium.
- **Managed Lanes** are lanes that have special operational characteristics and restrictions intended to manage the operations of the lanes. Management of the facility is typically a combination of physical design, which limits access and regulation, and may include pricing. Examples are:
  - HOV Lanes—exclusively used by transit, vanpools, and vehicles with a minimum number of occupants, typically two or three;
  - Reversible Express Lanes—change directions during peak periods to manage peak demand periods;
  - Direct Access Ramps—provide direct access to a managed lane (e.g., a direct access ramp that links an HOV lane to a park & ride facility);
  - Ramp Bypass Lanes—provide priority bypass of ramp meters for vehicles;
  - Trucks Only Lanes—used exclusively by trucks;
  - Transit Only Lanes or Bus Ways—used exclusively for transit;
  - Green Lanes—exclusively for vehicles that meet specified environmental impact levels (this management strategy will require careful study, since our HOV lanes are already at capacity);
  - Limited Access Highways—have limited access points; and
  - High-Occupancy Toll (HOT) or Tolled Express Lane—discussed in detail under Pricing Policy Options above.

    Specific performance measures: It is important to continuously review the definitions of the segments of the system to achieve the greatest travel time reliability without creating undue inefficiencies in the overall network.

  Reliability may be more useful measure than “delay;” some other measures include “average operating speeds,” “person throughput,” and “VMT reduction,” depending on facility type and improvement. Anticipated investment level is medium for conversion of existing lanes and high for construction of new lanes.

- **Increase Incident Response opportunities**: Detection, assistance, and clearing of incidents on the highway so as to assist travelers, increase safety, and reduce non-reoccurring delay caused by incidences.
  - This strategy is best served on limited access roadways where it is hard for drivers to find an alternative route to their destinations.
  - However, perhaps expand incidence response activities to high volume and accident-prone local streets and major arterials if appropriate.

  Specific performance measures are "response time to the scene," "time needed to clear an incident," "delay," and reduced "idle time." Anticipated investment level to achieve is medium to high.

- **Improve Traveler Information:** Providing real time and projection of travel conditions and transit information to the public to aid in their decision about how, when, and where to travel.

Reliability may be a more useful measure than "delay." Other measures include "speed/travel time." Anticipated investment level to achieve is medium to high.

Related Policies/Programs in Place

Federal Congestion Mitigation and Air Quality (CMAQ) program funding can be used for retrofits that reduce idling and associated energy use.

The MDOT, in cooperation with the MPOs, MDE and local government bodies, has the following in place with regards to promoting the purchase of fuel-efficient and low GHG vehicles:

- **Hybrid Vehicles:** MDOT and the State of Maryland have been purchasing hybrid vehicles to reduce fuel usage and improve air quality.
- **Hybrid Buses:** New buses powered by hybrid engines use much less fuel and emit fewer emissions. MTA has begun to put into service.
  - MTA will put 10 Hybrid buses into service as replacements for older buses between 2005 and 2008
  - By 2012, MTA will have 340 hybrid buses total in service.
  - MTA will replace all buses with hybrids, as the fleet ages and needs replacement.
  - While hybrid buses cost $200,000 more than a conventional full-size diesel bus, the average bus travels 250 miles a day 300 days a year, and as such fuel savings on operating the buses should compensate for the higher purchase cost.
- **Locomotive Refurbishing:**
  - MTA has purchased 26 remanufactured diesel/electric locomotives that meet TIER 2 standards.
  - Although not yet confirmed, emissions reductions of about 1/3 are expected for operating these remanufactured locomotives in the place of conventional buses.

With respect to reducing idling time, MDOT, in cooperation with the MPOs, MDE and local government bodies has the following in place:

- **Truck Stop Electrification (TSE):** Maryland already has 3 TSE locations with almost 300 spaces in service. Truckers do not need to idle their engines to heat, cool the cab, or obtain power while "out of service."
  - Between August 22, 2005 and March 13, 2008 the 3 TSE locations (Baltimore [63 spaces], Jessup [129 spaces] and Elkton [57 spaces]) operated 671,869 hours.
  - They saved 671,869 gallons of fuel.
  - 7,121 metric tons reduced, based on EPA emissions factor of 10,397 grams per hour (g/hour) (Source: IdleAire)
- **Idling Reduction Requirements:** Being pilot tested at major construction sites, including the International Code Council (ICC) project**.**

With respect to TMS, MDOT, in cooperation with the MPOs, MDE and local government bodies have the following in place

- **ITS,** currently in place on the Maryland interstate system, allows for a reduction in delay due to accidents, or breakdowns. According to the CHART report for 2006, the system in place reduced idle time for trucks and passenger vehicles as follows
  - Annual truck idle time reduced: –2,445,865 hours,
  - Daily truck idle time reduced: –9,407 hours,
  - Annual car idle time reduced: –35,090,766 hours,
  - Daily car idle time reduced: –134,964 hours, and
  - Benefits have been growing conservatively at 2% a year. By 2012 benefits should increase 10%–12%.
- **Traffic Signal Synchronization/Light-Emitting Diode (LED) signals**
  - LED modules have been routinely implemented since January 2006.
  - About 2,700 LED state signal locations will be in place between 2011 and 2015.
  - Existing signal synchronizations in 2008 have provided significant benefits in reducing network vehicle delays and fuel consumption (via reduced idling).
  - Timing changes and measurement improvements were calculated using Synchro traffic-timing software.

Type(s) of GHG Reductions

CO_2, black carbon

Estimated GHG Reductions and Net Costs or Cost Savings

Off-road

Table H-10 summarizes transportation sector off-road engine/vehicles baseline CO_2e emissions compared with a 15% by 2020 reduction program.

Table H-10. Transportation sector off-road engines/vehicles (goals)

	$MMtCO_2e$		
	2005	**2015**	**2020**
No action-trend (marine, air, rail, other)	2.69	2.81	2.95
GHG-reduction strategy			2.51
Reduction			0.44

$MMtCO_2e$ = million metric tons of carbon dioxide equivalent; GHG = greenhouse gas.

This option includes a mix of policies designed to reduce GHG emissions from off-road engines/vehicles. The costs and benefits of each of the individual policies are different.

These two technology approaches are used as examples of potential technology options available in the State of Maryland. Locomotive auxiliary engines and providing shore power for Ocean Going Vessels (OGV) have the potential to reduce emissions by 0.07 $MMtCO_2e$ in 2020, which is only 16% of the 0.44 reductions planned for this policy option. It is assumed that other technologies are available to reduce emissions at similar costs, and therefore the costs and benefits found in the example projects can be scaled up to achieve the necessary emissions reduction of 0.44 $MMtCO_2e$.

For example, options like locomotive auxiliary engines and providing shore power at port facilities typically have an upfront capital investment to purchase a more efficient engine, and the cost-savings results from reduced fuel usage compared with the original equipment. The length of payback periods for this capital investment is often the most important question when considering the feasibility of this type of option. Two examples of cost-effectiveness analyses for providing shore-power at a port and applying idle control technologies on switcher locomotives are provided below.

Shore-power is becoming a significant part of the green port strategies being implemented at ports on the west coast of the United States. For example, the Port of Long Beach has adopted a green port policy that is intended to guide the port's operations in a green manner. The port has committed to providing shore-power to all new and reconstructed container terminal berths and other berths, as appropriate. Through lease language, the port will require selected vessels to use shore-power and all other vessels to use low-sulfur diesel in their auxiliary generators. The primary method for providing shore-power at California ports is referred to as cold ironing. Cold ironing refers to shutting down auxiliary engines on ships while in port and connecting to electrical power supplied at the dock. Without cold ironing, auxiliary engines run continuously while a ship is docked, or hotelled at a berth to power lighting, ventilation, pumps, communication, and other onboard equipment. Ships can hotel for several hours or several days.

In an example of cold ironing, an analysis was done on the cost-effectiveness of three ships that each visited port 17 times during the year. On every trip they were electrified for their 60 hours in port, saving a total of 1,478 metric tons of fuel. These fuel savings resulted in a GHG reduction of 4,741 tons of carbon dioxide equivalent (tCO_2e). Given the estimated annual costs of $1,583,000, this means that there are costs of $334/$tCO_2e$ avoided through fuel consumption. However, the production of electricity for use in the ship will reduce the GHG savings with this approach. Using Maryland emissions factors, the GHG benefits of this program would be reduced to only 1,051 tCO_2e annually. This would mean a cost of \$1,506/tCO_2e reductions from the cold ironing method.

There are several other important factors to consider on the issue of cold ironing. This process has significant up-front costs. While the analysis above considers the annual costs of the program over a 10-year period, the initial costs are considerable. In this example, the port requires an initial investment of \$4.5 million to provide electrification, and each of the three ships must undergo a \$1.5 million modification to accept electricity from the ports. If very few ships make this modification, then the costs per tCO_2e would increase dramatically. Labor and electricity are also part of the cost estimate, though these are less of a problem in terms of upfront capital. Finally, the example is of ships that use the port 17 times a year. If a ship does not frequent a particular port more than a few times a year, it is unlikely that they would want to undertake the modification. And even if the ship were equipped to engage in cold ironing, the benefits of such a case would be far reduced.

Switcher locomotives are used to move materials within a rail yard. Switcher locomotives are idling approximately 12 hours a day, to avoid problems with shutdown and possible freezing in cold weather. Installing auxiliary engines in these locomotives can decrease fuel consumption, which helps reduce GHG emissions, as well as reducing local air pollutants and noise. This reduction is achieved through reduction of fuel consumption while idling. Installing an auxiliary engine is highly cost-effective, with a payback period of 2 to 2.5 years without taking any environmental benefits into account.

Idling with the locomotive's main engine takes about 3 gal/hour in warm weather and 11 gal/hour in cold weather (a higher setting is required to keep the engine from freezing). Assuming 4 months of cold weather a year, and an average of 335 active days annually for a locomotive, this would result in a savings of 19,564 gallons of diesel fuel. For a railyard in a warmer climate where no warm weather idling is ever used, then 8,844 gallons of fuel would be saved annually.

This modification has an upfront capital cost of \$35,500. Using a 5% discount rate and a 10-year life for the engine, this would mean annualized costs of \$4,597.25. In a cold climate, the auxiliary engine would have an annualized savings of 19,564 gallons. This would be a GHG emissions reduction of 200.54 tCO_2e. Even in the scenario of a warmer climate, with no cold-weather idling, there would still be an emissions reduction of 90.65 tCO_2e over the year.

When avoided fuel costs are taken into account, the low costs of this program become obvious. Given that 19,564 gallons of fuel are saved annually in the cold weather scenario, using Annual Energy Outlook (AEO) energy prices, this would be a net annual savings of over \$42,000. This would mean a net savings of \$209.45 for every tCO_2e avoided. In the less optimistic warm weather scenario, this would still result in an annual savings of nearly \$16,500, or \$181.66/tCO_2e avoided.

Costs of alternative fuels strategies for off-road equipment would be expected to be similar to those shown under the cost analysis for TLU-4.

When creating the net present value (NPV) estimate for TLU-10, the quantifiable emissions reductions possible through cold ironing of boats and alternative engines in locomotives did not reach the emissions reductions goal. Emissions from non-road sources were estimated at 2.95 $MMtCO_2e$ in Maryland in 2020, but of these, only 0.93 were from ships in harbor and 0.06 were from rail. For the ships, this number was further reduced because only 30% of emissions come from OGVs while hotelled. The alternative engines in locomotives could only reduce idling emissions of switcher locomotives, which make up only 9% of total rail emissions. It is likely that other technologies do exist to reduce off-road emissions, but they are not quantified in this analysis.

On-road

We assume that the new technologies reduce emissions by 7.5% in 2020, with a smooth ramp-up to 2020. Table H-11 shows the path to implementation and the expected emissions savings that result from these on-road technology improvements.

Table H-11: On-road Emissions Reductions through Transportation Technologies

Year	Onroad Emissions (with LEV standards)	Reduction Pathway	Emissions Reductions ($MMtCO_2e$)
2010	31.98		0.00
2011	32.24		0.00
2012	32.32	0.5%	0.16
2013	32.23	1.0%	0.32
2014	32.09	1.5%	0.48
2015	31.95	2.5%	0.80
2016	31.85	3.5%	1.11
2017	31.75	4.5%	1.43
2018	31.70	5.5%	1.74
2019	31.72	6.5%	2.06
2020	31.81	7.5%	2.39
Total			**10.50**

LEV = low emission vehicle; $MMtCO_2e$ = million metric tons of carbon dioxide equivalent.

Given the difficulties in improving vehicle technologies and the time lag that often results in such measures, the policy was not predicted to achieve reductions until 2012, growing by 0.5% until 2014 and then growing 1% every year until 2020. A variety of technology measures are available to provide these types of reductions, such as improved valve and cylinder operations, improved transmissions, higher efficiency fuel combustion and improved vehicle accessories (such as air conditioning compressor, tires, and alternator) (CCAP).

Data Sources:

California Air Resources Board (ARB). 2006 (Mar.). Evaluation of California Ocean-Going Vessels at California Ports, Stationary Source Division, Project Assessment Branch.

US EPA. 2005 (June). Locomotive switcher idling and idle control technology. Available at: http://www.epa.gov/NE/eco/diesel/assets/pdfs/locomotive-factsheet.pdf

US EPA. 2004 (Mar.). Case study: locomotive idle reduction project. Available at: http://www.epa.gov/smartway/documents/420r04003.pdf

Center for Clean Air Policy. 2007. CCAP Transportation Guidebook. Part 2 Vehicle Technology and Fuels. Available at: http://www.ccap.org/safe/guidebook/downloads/CCAP%20Transportation%20Guidebook%20(2).pdf

Quantification Methods: For example, full LCA with supply/demand equilibrium adjustments on TWG approval.

Key Assumptions: The cold-ironing project estimate makes assumptions regarding the level of use of cold ironing facilities, the GHG emissions of OGVs, and the amount of emissions from OGVs while in the harbor. These estimates were based on previous analyses of emissions reduction projects in New York and Long Beach. If the factors involved in Maryland harbors are significantly different, then the costs and emissions savings would likely change.

The locomotive idling project makes assumptions of the fuel savings and level of use of an auxiliary engine on a locomotive. These estimates are based on analyses done by the US EPA, and from a case study in Chicago. Maryland may have significantly different factors, which would change the estimates of costs and emissions savings.

Key Uncertainties

New US EPA emission standards affecting rail locomotive and commercial marine vessel criteria pollutant emissions have recently been promulgated. These emission standards are expected to reduce fine particulate matter (PM) and nitrogen oxides (NO_x) emissions after 2010.

Additional Benefits and Costs

Cold ironing applied in the Port of Baltimore would provide significant co-benefits via reducing criteria air pollutant emissions, including NO_x, PM, volatile organic compounds (VOC), and sulfur dioxide (SO_2). Locomotive idling reduction can have co-benefits in the form of decreased noise, as well as reduced criteria air pollutant emissions such as NO_x, PM, VOC, and SO_2.

Feasibility Issues

The benefits of cold ironing in the Port of Baltimore depend on the frequency of visits by ships to that port. Installing auxiliary engines on switchyard locomotives is feasible because it is already being done within Maryland and in other states.

Status of Group Approval

Approved.

Level of Group Support

Unanimous.

Barriers to Consensus

None.

TLU-11. Evaluate the Greenhouse Gas (GHG) Emissions Impacts of Major Projects

Policy Description

The state will require GHG emissions evaluation of all TLU relevant state and local, major capital projects.

Policy Design

Goals:

Understand the impacts of new capital projects on the Governor's GHG commitment by performing a GHG impacts build/no-analysis on all major capital projects.

Where appropriate, the build-no-build will be accompanied by analysis of potential alternatives (such as, transit-oriented land use and investment); adding toll lanes and express bus; HOT lanes; and a hybrid transit-oriented HOT lane, or a rail and express bus scenario.

Timing: As soon as this policy can be implemented.

Parties Involved: Seek federal guidance for models and best practices.

Implementation Mechanisms

Develop guidance for the state and other large capital project sponsors to use.

Related Policies/Programs in Place

A key part of the Maryland GHG inventory and forecast is a 2006–2020 VMT forecast that was developed by the MDE. The MDE VMT forecast used Highway Performance Monitoring System (HPMS) historical traffic-volume forecasts by county and facility type, for the 1990 to 2005 period, to establish a trend line. An extrapolation of this trend line was used to estimate VMT for 2006 to 2020. This trend-based extrapolation method provides higher estimates of 2020 Maryland VMT by county than is included in the MPO forecasts for their long range transportation-planning process in Metro Washington and Baltimore. Because the latest MPO forecasts include the VMT estimates associated with major projects such as the ICC, Base Realignment and Closure (BRAC), and I-95 expansion, the higher VMT forecasts in the statewide VMT forecast used in this process are also expected to include the effects of these projects. Nevertheless, it is recognized that an extrapolated trend line VMT forecasting method is too aggregated to allow the group to discern the effects that might be attributable to any single project.

No consensus was reached about whether it makes sense to develop estimates of the VMT impacts of the three recent major projects in Maryland on GHG emissions.

However, the TWG members recommend that best practice planning tools be used in the future to fully evaluate the effects of new major projects to determine the expected effects on GHG emissions before these projects proceed.

Type(s) of GHG Reductions

N/A; policy does not provide emissions reductions on its own.

Estimated GHG Reductions and Net Costs or Cost Savings

N/A; policy does not provide emissions reductions on its own.

Key Uncertainties

None cited.

Additional Benefits and Costs

None cited.

Feasibility Issues

None cited.

Status of Group Approval

Approved.

Level of Group Support

Unanimous.

Barriers to Consensus

None.

Acronyms and Abbreviations

AAA	American Automobile Association
AASHTO	American Association of State Highway and Transportation Officials
AEO	Annual Energy Outlook
AFCI	Average Fuel Carbon Intensity
AFV	alternative-fuel vehicle
ANL	Argonne National Laboratory
ARB	[California] Air Resources Board
ATM	Active Traffic Management
B&P	Baltimore and Potomac
B5	5% bio-diesel fuel blend
BAU	business as usual
BTL	biomass to liquids
BRAC	Base Realignment and Closure
BRT	Bus Rapid Transit
BWI	Baltimore Washington International Airport
C&T	cap-and-trade
CCAP	Center for Clean Air Policy
CCS	Center for Climate Strategies
CEC	California Energy Commission
CEF	carbon emission factor
CHART	Coordinated Highways Action Response Team
CMAQ	Congestion Mitigation and Air Quality
CNG	compressed natural gas
CO_2	carbon dioxide
CO_2e	carbon dioxide equivalent
CTL	coal to liquids
CTP	Consolidated Transportation Program
DBM	[Maryland] Department of Budget and Management
DHCD	[Maryland] Department of Housing and Community Development
DMU	Diesel Multiple Unit
E10	10% ethanol fuel blend
E85	a blend of 85% ethanol and 15% gasoline
EISA	Energy Independence and Security Act of 2007
EPAct	Energy Policy Act of 1992
EPI	Economic Policy Institute
EV	electric vehicle
ETAAC	[California] Economic and Technology Advancement Advisory Committee
F-T	Fischer-Tropsch
FAME	Fatty Acid Methyl Ester
FCV	fuel cell vehicle
FFV	flexible-fuel vehicles
FHWA	Federal Highway Administration
FRB	Federal Reserve Bank [of Richmond]

GHG	greenhouse gas
GPS	global positioning system
GMAC	General Motors Acceptance Corporation
GREET	Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation
GRH	Guaranteed Ride Home
GSP	Gross State Product
GWI	global warming intensity
HDV	heavy-duty vehicle
HEV	hybrid electric vehicle
HOT	High-Occupancy Toll
HOV	high-occupancy vehicle
HPMS	Highway Performance Monitoring System
NSRC	[North Carolina] Highway Safety Research Center
ICC	International Code Council
ICE	internal combustion engine
IRS	Internal Revenue Service
ITS	intelligent transportation systems
LAB	League of American Bicyclists
LCA	life cycle analysis
LDV	light-duty vehicle
LED	light-emitting diode
LEM	Lifecycle Emissions Model
LEV	low-emission vehicle
LGFS	low greenhouse gas fuel standard
LUTAQH	Land Use, Transportation, Air Quality, and Health
MARC	Maryland Rail Commuter Service
MAROps	Mid-Atlantic Rail Operations
MCCC	Maryland Climate Change Commission
MCTP	Maryland Comprehensive Transit Plan
MDE	Maryland Department of Environment
MDOT	Maryland Department of Transportation
MDP	Maryland Department of Planning
MDTA	Maryland Transportation Authority
MPO	metropolitan planning organizations
MTA	Maryland Transit Administration
MTBE	methyl tert-butyl ether
MTP	Maryland Transportation Plan
MWCOG	Metropolitan Washington Council of Governments
MWG	Mitigation Working Group
N/A	not applicable
NAP	National Academies Press
NARP	National Association of Rail Passengers
NAS	National Academy of Science
NCHRP	National Cooperative Highway Research Program
NESCAUM	Northeast States for Coordinated Air Use Management

NO_x	nitrogen oxides
Non-SOV	non-single-occupant vehicle
NPV	net present value
NRC	National Research Council
NS	Norfolk Southern
OGV	Ocean Going Vessels
OSG	Office of Smart Growth
PAYD	Pay-As-You-Drive
PHEV	plug-in hybrid electric vehicles
PIRG	Public Interest Research Group
PM	particle matter
PSRC	Puget Sound Region Council
PTA	Parent-Teacher Association
RFF	Resources for the Future
RFG	reformulated gasoline
SHA	[Maryland] State Highway Administration
SO_2	sulfur dioxide
SOV	single-occupant vehicle
SRTS	Safe Routes to Schools
TLU	Transportation and Land Use
TMD	Transportation Management Districts
TMO	Transportation Management Organizations
TMS	Transportation Management Systems
TOD	transit-oriented development
TRB	Transportation Research Board
TSE	Truck Stop Electrification
TTF	Transportation Trust Fund
TWG	Technical Working Group
UC	University of California
UCLA	University of California, Los Angeles
US DOE	U.S. Department of Energy
US DOT	U.S. Department of Transportation
US EPA	U.S. Environmental Protection Agency
VMT	vehicle miles traveled
VOC	volatile organic compounds
VTPI	Victoria Transport Policy Institute
WABA	Washington Area Bicyclist Association
WTW	well to wheels

Units of Measure

$/t CO_2e	dollars per ton of carbon dioxide equivalent
g CO_2e/MJ	carbon dioxide equivalent per megajoule of fuel delivered to the vehicle
g/hour	grams per hour
MMt	millon metric tons

$MMtCO_2e$	million metric tons of carbon dioxide equivalent
tCO_2e	tons of carbon dioxide equivalent

Maryland Climate Action Plan

Appendix D-5

Cross-Cutting Issues

Cross-Cutting Issues

Summary List of Policy Option Recommendations

Option No.	Policy Option	GHG Reductions ($MMtCO_2e$)			Net Present Value 2008–2020 (Million $)	Cost-Effective-ness ($/tCO_2e$)	Level of Support
		2012	2020	Total 2008–2020			
CC-1	GHG Inventories and Forecasting	*Not Quantified*					Unanimous
CC-2	GHG Reporting and Registry	*Not Quantified*					Unanimous
CC-3	Statewide GHG Reduction Goals and Targets	*Not Quantified*					Unanimous
CC-4	State and Local Government GHG Emissions (Lead-by-Example)	*Not Quantified*					Unanimous
CC-5	Public Education and Outreach	*Not Quantified*					Unanimous
CC-6	Tax and Cap Policies	*Not Quantified*					Addressed by ES TWG
CC-7	Review Institutional Capacity to Address Climate Change Issues, Including Seeking Funding for Implementation of Climate Action Panel Recommendations	*Not Quantified*					Unanimous
CC-8	Participate in Regional, Multi-State, and National GHG Reduction Efforts	*Not Quantified*					Unanimous
CC-9	Promote Economic Development Opportunities Associated with Reducing GHG Emissions in Maryland	*Not Quantified*					Unanimous
CC-10	Create Capacity to Address Climate Change Issues in and "After Peak Oil" Context	*Not Quantified*					Unanimous
CC-11	Evaluate Climate Change Policy Options to Determine Projected Public Health Risks/Costs/Benefits						Unanimous

GHG = greenhouse gas; $MMtCO_2e$ = million metric tons of carbon dioxide equivalent; $/tCO_2e$ = dollars per metric ton of carbon dioxide equivalent.

CC-1. GHG Inventories and Forecasting

Policy Description

Greenhouse gas (GHG) emissions inventories and forecasts are essential for understanding the magnitude of all emission sources and sinks (both natural and those resulting from human activities), the relative contribution of various types of emission sources and sinks to total emissions, and the factors that affect trends over time. Inventories and forecasts help inform state leaders and the public on statewide trends, provide opportunities for mitigating emissions or enhancing sinks, and help verify GHG reductions associated with the implementation of action plan initiatives.

Policy Design

The Cross-Cutting Issues Technical Work Group (CC TWG) recommends that the state institute formal GHG inventory and forecast and GHG reporting functions.

Goals:

- Develop a periodic, consistent, and complete inventory of emission sources and sinks on a frequent basis. To the degree that data and methods allow, the inventory should include all natural and man-made emissions generated within the boundaries of the state (e.g., a production-based inventory approach) as well as emissions associated with energy imported into and consumed in the state (e.g., a consumption-based inventory approach). The inventory should, through performance metrics and differences in year-to-year emissions, provide a way of documenting and illuminating trends in state GHG emissions.
- Develop a protocol for preparing the statewide emissions and sinks inventory.
- Develop a periodic, consistent, and complete forecast of future GHG emissions in at least 5- and 10-year increments extending at least 20 years into the future. The GHG forecast should be updated periodically. The GHG forecast should reflect projected growth as well as the implementation of scheduled mitigation projects. In the forecast of future GHG emissions, the treatment of uncertainties should be transparent, be as consistent as possible across sectors and time and, to the extent possible, reflect multiple scenarios. The estimation methods should be consistent with those used to develop the emissions inventory and should reflect best practice.
- Develop a standardized protocol for the periodic forecasting of statewide GHG emissions.

Timing: This function should be implemented as soon as allowed by current funding and supplemented in 2008 with pertinent appropriation requests. The institutional capability should be created as soon as possible by Executive Order and by policy and budget legislation. A supplemental budget should be introduced in the 2008 session of the General Assembly. An Executive Order should be issued in 2008. To the extent necessary, legislation should be enacted in 2009.

Parties Involved: All GHG emission sources and sinks (both natural and those resulting from human activities) should be included in the inventory and forecast.

Other: Not applicable.

Implementation Mechanisms

Seek funding through an FY 2008 supplemental bill and full funding in the FY 2009 budget request. Current agency actions should be used as a basis for expansion of efforts. A standardized protocol should be developed. Maryland Department of the Environment (MDE) does not currently track vehicle emissions, which should be included in the protocol. *The Climate Registry* is developing a protocol, but this process is happening slowly.

Related Policies/Programs in Place

MDE currently has 3 full-time equivalents (FTEs) working in the air quality planning and modeling program. The existing agency program staffing and financing need to be expanded to address GHGs (see Option CC-7).

Type(s) of GHG Reductions

Not applicable.

Estimated GHG Reductions and Net Costs or Cost Savings

Not applicable.

Key Uncertainties

Long-term projections of GHG emissions may have uncertainties associated with them.

Additional Benefits and Costs

None identified at this time.

Feasibility Issues

Not applicable.

Status of Group Approval

Approved.

Level of Group Support

Unanimous.

Barriers to Consensus

None.

CC-2. GHG Reporting and Registry

Policy Description

GHG reporting reflects the measurement and reporting of GHG emissions to support tracking and management of emissions. GHG reporting can help sources identify emission reduction opportunities and reduce risks associated with possible future GHG mandates by moving up the learning curve. Tracking and reporting of GHG emissions can also help in the construction of periodic state GHG inventories. GHG reporting is a precursor for sources to participate in GHG reduction programs, to provide opportunities for recognition, and to create a GHG emission reduction registry, as well as to secure "baseline protection" (i.e., credit for early reductions).

A GHG registry enables recording of GHG emissions reductions in a central repository with "transaction ledger" capacity to support tracking, management, and "ownership" of emission reductions; establishes baseline protection; enables recognition opportunities; and provides a mechanism for regional, multi-state, and cross-border cooperation. Properly designed registry structures also provide a foundation for possible future trading programs.

Policy Design

- Develop and manage a common GHG emissions reporting system with high integrity that is capable of supporting multiple GHG emissions reporting and emissions reduction policies for its member states, tribes, and reporting entities.
- Provide an accurate, complete, consistent, transparent, and verified set of GHG emissions data from reporting entities, supported by a robust accounting and verification infrastructure.
- Ensure that reporting occurs annually on a calendar-year basis for all six traditional GHGs and, to the extent possible, for black carbon.
- Require reporting of direct emissions; phase in reporting of emissions associated with purchased power and heat, and allow voluntary reporting of other indirect emissions.
- Make every effort to maximize consistency with federal, regional, and other states' GHG reporting programs.
- Verify GHG emissions reports through current certification processes, including federal CFR Part 75 data quality assurance procedures where applicable. Data not subject to comprehensive protocols may need third-party certification.
- Include provisions to exclude de minimis emission sources, where appropriate.
- Allow project-based emissions reporting when properly identified as such and when quantified with rigorous consistency.
- Provide full transparency of reported emissions in the reporting program.
- Participate in the national *Climate Registry, which* Maryland has already joined.
- Strive for maximum consistency with other state, regional, and/or national efforts; provide flexibility as GHG mitigation approaches evolve; and provide guidance to assist participants.

Goals: Implement a GHG registry for Maryland sources as soon as possible.

Timing: As soon as possible.

Parties Involved: Probably overseen by MDE; costs shared by participants benefiting from the registry.

Other: Not applicable.

Implementation Mechanisms

- Build the GHG emission reduction requirements into air quality permits.
- Address all GHG emissions, not just carbon dioxide (CO_2). Develop protocols for reporting.
- Allow for calculation of GHG emissions, if the MDE determines that is appropriate.

Related Policies/Programs in Place

Annual emission certification requirements for large sources for criteria pollutants and acid rain sources are available. Need to expand them to more sources and all GHG emissions.

Type(s) of GHG Reductions

Not applicable.

Estimated GHG Reductions and Net Costs or Cost Savings

Not applicable.

Key Uncertainties

The extent to which voluntary reporting will actually occur is unknown. Also there are reporting difficulties related to monitoring.

Additional Benefits and Costs

None identified at this time.

Feasibility Issues

Continued development of the technology and methodology is needed to accurately monitor and quantify sources and sinks, both natural and those resulting from human activities.

Status of Group Approval

Approved.

Level of Group Support

Unanimous.

Barriers to Consensus

None.

CC-3. Statewide GHG Reduction Goals and Targets

Policy Description

Governor O'Malley's signed Executive Order 01.01.2007.07 in April 2007. It created the Maryland Commission on Climate Change (MCCC) and established the presumptive GHG reduction goals for the State. Maryland's GHG emissions are to be reduced to 1990 levels by 2020 and reduced to 80% of 2006 levels by 2050. An Interim Report to the Governor and General Assembly (December 2007) resulting from the first phase of the MCCC process recommends revised goals that are more ambitious than those in the original order. (These proposed goals are described below.)

After reviewing recent reports issues by the International Panel on Climate Change (IPCC) and a summary of studies compiled by the Scientific and Technical Working Group, the Mitigation Working Group has concluded that it is absolutely necessary to adopt "stretch" goals for reducing Maryland's GHG emissions. Reductions occurring earlier in time have much more mitigation value than reductions occurring later in time. Reductions in the 20% to 50% range by 2020 (2006 base) appear to be needed to avoid the IPCC's most catastrophic forecasts. Specific targets for GHG reductions by 2012–2015, 2020, and 2050 are essential to provide a framework for Maryland's reduction efforts. These goals should be relative to Marylanders' consumption-based GHG emissions. Because new data, information, and studies will become available in future years, the Mitigation Working Group recommends in-depth review of the targets every 4 years.

The goals presented below reflect the recommendations included in the MCCC's Interim Report to the Governor.

Policy Design

Goals: By Executive Order and legislation, the Governor and General Assembly should adopt the following specific goals for reducing Maryland's GHG emissions:

- 10% below 2006 GHG emission levels (using a consumption-based approach) by 2012
- 15% below 2006 levels by 2015 (both 2012 and 2015 goals to be used as reduction goals for Maryland's Climate Action Plan.)
- 25%–50% below 2006 levels by 2020 (25% to be used as the "minimum" enforceable regulatory driver for the Global Warming Solutions legislation; 50% to be used as a science-based, nonregulatory reduction goal for Maryland's Climate Action Plan.) Programs to implement the legislation would reward market-based reductions above 25%.
- 90% below 2006 levels by 2050 (a science-based regulatory goal in the Global Warming Solutions legislation that would provide a driver for research and development of climate neutral technology, programs, and innovations.)
- Mid-course reviews (conduct a science-based review of the goals at least every 4 years starting in 2012).

- Track progress from 1990 levels.

Timing: The goals should be adopted in 2008.

Parties Involved: All state and county governments and the citizens of Maryland.

Other: The Executive Branch should issue a report to the public every second year, beginning in 2010, summarizing Maryland's programs and activities for GHG reductions and evaluating Maryland's progress in achieving the state's mitigation targets.

Implementation Mechanisms

Propose a legislative initiative in the 2008 session with these goals included. Include a definition of GHG in the legislation.

Related Policies/Programs in Place

Governor's Executive Order and the MCCC Interim Report.

Type(s) of GHG Reductions

Not applicable.

Estimated GHG Reductions and Net Costs or Cost Savings

Not applicable.

Key Uncertainties

General Assembly adoption of the goals during the 2008 session is not ensured. Citizens embracing their roles in altering habits and choices as needed to achieve the reduction targets. The degree to which the assumptions to meet targets will hold true is undetermined. Will need to review underlying assumptions in the biennial reviews and adjust them accordingly in order to make progress toward achieving targets.

Additional Benefits and Costs

Establishing state GHG reduction goals in Maryland and many other states will encourage the federal government to adopt a national GHG program. It will give Maryland a head start on implementing any national program that is eventually put in place. There may also be unforeseen economic costs associated with implementation of the measures recommended herein.

Feasibility Issues

Timely implementation of all recommendations. Availability of new technology essential to several GHG reduction programs.

Status of Group Approval

Approved.

Level of Group Support

Unanimous.

Barriers to Consensus

None identified at this time.

CC-4. State and Local Government GHG Emissions (Lead-by-Example)

Policy Description

The State of Maryland and municipal and county governments can provide leadership in moving the state forward by adopting policies that improve the energy efficiency of public buildings, facilities, and operations and through procurement processes. The proposed RCI-4 policy provides energy efficiency targets that are much higher than code standards for new state-funded and other government buildings, facilities, and operations and also sets targets for existing buildings. This option identifies energy efficiencies and GHG reductions that can be achieved through governmental procurement and purchasing processes. Taken together, these measures can result in significant reductions of GHG emissions by governmental entities. As analyses are developed by government agencies about their carbon footprints, they can implement the procurement and purchasing measures presented here, the efficiency measures noted in RCI- 4, or numerous other options described throughout the report in order to reduce overall GHG impacts.

The following are potential elements of this policy:

- Ensure that state and local governments consider comprehensive environmental and public health impacts as well as energy efficiencies.
- Set a goal for state and local governments to purchase goods from companies that practice energy use reduction and sequestration of carbon dioxide.
- Encourage citizens to place less emphasis on consumption and promote the use of materials that are compostable, recyclable, and reusable.
- Ensure that contracting procedures do not discriminate against reusable, recycled, or environmentally preferable products with sufficient and specific justification.
- Review environmentally preferable products to determine the extent to which they may be used by state and local governments and their contractors.
- Review and revise contracting procedures to maximize the specification of designated environmentally preferable products where practicable.
- Adopt purchasing specifications that comply with U.S. Environmental Protection Agency Comprehensive Procurement Guidelines for preferred products.
- Use Recovered Materials Advisory Notices (RMAN) as a reference for determining the recycled content specifications for these products.
- Make sure that these initiatives do not adversely impact public health.

Policy Design

Goals: State and local government lead-by-example initiatives described here and in the RCI TWG Appendix will serve as models for achieving significant GHG reductions through procurement and other processes.

Timing: See above.

Parties Involved: State and local governments, Maryland Municipal League, Maryland Association of Counties, Public Service Commission, and environmental advocacy organizations.

Other: Keep public health issues in mind.

Implementation Mechanisms

- Evaluate and minimize GHG emissions along the entire supply chain and increase the efficiency of operations through purchasing and end-of-life disposal or recycling. Establish policies for purchasing only energy efficient products and services by specifying ENERGY STAR–certified and other efficient equipment and appliances, by stocking only energy efficient and environmentally preferable products in Central Stores, and by planning for end-of-life disposal of equipment and other goods when initial purchase is made. Purchase items that can be recycled rather than thrown away.
- Develop and use renewable energy resources. Evaluate the potential for direct use of solar, wind, biomass, geothermal, and hydro power to meet the needs of state government operations. Take advantage of these renewable resources whenever it is cost-effective to do so and as a means to lead by example in investing in these systems when it is practical to do so.
- Implement by December 31, 2008, a requirement that state-owned or leased facilities use life cycle costing, including full consideration of future energy costs, in the selection and implementation of building designs and components for both new and renovated space or for the selection of replacement components. Require that the most cost-effective design, equipment, or component options be chosen.
- Evaluate and minimize GHG emissions along the entire supply chain and incorporate consideration of comprehensive environmental impacts into state and local government purchasing and contracting practices.
- Purchase items that can be composted, recycled, or reused rather than thrown away.
- Purchasing and contracting practices should consider comprehensive environmental impacts as well as energy efficiency. (Such as products' embodied carbon and recycled content; products that are produced and available locally and the GHG track record of suppliers.)

Related Policies/Programs in Place

Montgomery County Government and Board of Education, Bill 17-06, and Green School Focus.

Type(s) of GHG Reductions

Not applicable.

Estimated GHG Reductions and Net Costs or Cost Savings

Data Sources: Not applicable.

Quantification Methods: Not applicable.

Key Assumptions: Not applicable.

Key Uncertainties

Government determination to adopt and implement the required practices.

Additional Benefits and Costs

Helps establish and stimulate a green services and products industry in Maryland.

Feasibility Issues

Implementation costs of start-up for public–private sectors, depending on the level of certification and life cycle costs.

Status of Group Approval

Approved.

Level of Group Support

Unanimous.

Barriers to Consensus

None.

CC-5. Public Education and Outreach

Policy Description

Public education and outreach is vital to fostering broad awareness of climate change issues and effects (including co-benefits, such as clean air and public health) among the state's citizens. Such awareness is necessary to engage citizens, businesses, and institutions in actions to reduce GHG emissions. Public education and outreach efforts should be designed to reinforce state climate change policies and build upon existing outreach on climate change and related issues.

Due to the positive-feedback nature of climate change, massive, early actions are imperative. For example, a ton of carbon dioxide emission reduction this year is more effective in slowing warming than the same reduction the next year and is *much* more effective than the same reduction 5 years later. For this reason, the proposed efforts focus on energy conservation and efficiency—which can be implemented now and have immediate effects—and purposely leave out renewable energies and new climate-friendly technologies. These technologies may require substantial investments and may not be economically viable at present. The TWG recommends that they be considered when the policies are updated in the future. Furthermore, because early actions are important, the TWG recommends that the state not wait to perfect its plans before implementation. Quick implementation requires that the state plan a little, do a little, and let actions, results, and mistakes help stimulate more widespread actions.

Achieving a meaningful reduction in GHG emissions requires substantial efforts in conservation and energy efficiency. This means behavioral and life style changes in a broad spectrum of the public. State-sponsored public education and outreach alone will not result in behavioral and life style changes in the public. Repeated community actions, combined with economic incentives and disincentives provided by other state climate change policies, are the foundation for behavioral and life style change. This public education and outreach policy is designed to provoke such actions.

Policy Design

Segments of the public engaging in different activities have different concerns about climate change; the TWG recommends that public education and outreach efforts deliver messages to them in different ways. Many elements of the education and outreach efforts described below are either underway or ready to go. The state should consider forming a task force on climate education and outreach to fast-track implementation of many of these items.

The TWG recommends that the state build upon current educational efforts and action campaigns of state agencies, utilities, and nonprofit organizations. These organizations understand their offerings; enhanced resources from the state will reinforce their efforts to encourage Maryland residents and businesses to take action. The combination of efforts by the state, nonprofits, educational institutions, and utilities should ensure that public education and outreach efforts reach all segments of the public. Organizations should also ensure that they provide scientifically based factual information to users.

The TWG recommends that the state tap into the science and technology expertise from institutions in the state (e.g., The Johns Hopkins University School of Public Health, Goddard Space Flight Center, National Oceanic and Atmospheric Administration, and The University of Maryland) to develop information needed for public education and outreach. Many scientists from these institutions are deeply concerned about climate change and are disappointed at the lack of visible leadership on this issue from all levels of government thus far. They will be eager to volunteer their services when they are called upon.

Environmental nonprofits and environmental organizations within the faith communities are also poised to support action initiatives from the state when it shows visible leadership and the urgency that climate change calls for. The TWG recommends that the state tap into their support to organize massive community actions in conservation and energy efficiency.

1. State, County, and Local Government Initiatives

Educate and coordinate legislatures and agencies on climate change, conservation, and energy efficiency for government facilities, operations, and transportation. For example, achieve measurable GHG reduction through

- Lighting, indoor temperature, insulation, hot water temperature, and water consumption;
- Reducing paper consumption (e.g., by printing multiple slides on a page and using both sides of the paper);
- Reducing consumption of single-use containers (e.g., drinks in plastic bottles and cans);
- Using fuel-efficient vehicles; and
- Growing trees in place of lawns.

Goals: Legislatures and government agencies reinforce and further the state goals and serve as role models for citizens in conservation and energy efficiency; measurable GHG emission reduction.

Timing: Complete a plan in 1 month, and start implementation in 3 months.

Parties Involved: State, county, and local government agencies and legislatures.

Implementation Mechanisms:

- Develop informational material (brief, specific, and actionable guidelines) appropriate for this target audience.
- Deliver information and guidelines on climate friendly measures to department secretaries, managers, and building and grounds managers to stimulate actions in conservation and energy efficiency.
- Conduct periodic inspections to reinforce guidelines.

Cost: Not available at this time.

2. State K-12 Education Initiative

Develop Maryland-specific lessons on climate change, energy conservation, and energy efficiency aligned with the Voluntary State Curriculum and Core Learning Goals. The modules will reflect age-appropriate inquiry and problem-based learning concepts and activities that result in actions in conservation and energy efficiency. Modules or lessons may include

- Climate change science,
- Climate change and its implications on natural and human systems (e.g., social, political, and public health impact),
- Renewable energies and climate-friendly technologies, and
- Individual and group actions that positively and negatively affect natural systems.

Encourage schools in other states to adopt these teaching modules.

Goals: High awareness in climate change and climate-friendly behavior in students and their families.

Timing: Complete the plan in 2 months, issue grants to develop teaching modules in 4 months, and start delivering teaching in the 2009 school year.

Parties Involved: Maryland State Department of Education (MSDE), MDE, and county school boards.

Implementation Mechanisms: Delegate the MSDE to coordinate this initiative. Issue grants to experts to develop Maryland-specific teaching modules. Identify existing teaching materials that address general climate change concepts and make these available through the MSDE Environmental Education Web site. Set up a Web site (e.g., as part of the MSDE Web site) to host modules for teachers to download to eliminate distribution costs.

Delegate community colleges and state public colleges and universities to train teachers.

Cost: Not available at this time.

3. Governor's Regional Environmental Education Network (GREEN)

The MSDE has been planning for the formation of this group (the plan has not yet been presented to the Governor). This group, with county and local chapters, can coordinate environmental groups into concerted efforts and draw higher visibility to climate actions from the public. This group will attract volunteers from

- Environmental nonprofits,
- Faith communities and social and civic groups,
- K-12 school students in fulfilling community services,
- College voluntary interns, and
- Adult volunteers.

This group will call on and coordinate environmental nonprofits (e.g., Sierra Club, Chesapeake Bay Foundation) and environmental organizations in the faith communities (e.g., The Eco-Justice Program, Greater Washington Interfaith Power and Light) to educate and organize the larger populations for widespread conservation and energy efficiency actions.

Goals: High awareness on climate change and climate-friendly behavior in citizens and widespread community actions on sustainability and energy conservation; measurable GHG emission reduction.

Timing: Complete the plan in 1 month, and start implementation in 3 months.

Parties Involved: State and county departments of environment and environmental groups.

Implementation Mechanisms: Start the implementation with a conference of parties interested in GREEN (e.g., environmental organizations) and establish its charter. With some financial support from the state government for coordination, the group will be mostly sustained by volunteers and private donations. Involve the group in other public education and outreach efforts. Seek support from utilities for training members to conduct energy audits, demonstrate conservation and energy efficiency, and analyze and present cost savings. Aim to nurture the group to a level of maturity so that it no longer needs state government support in 3 years.

Cost: Not available at this time.

4. Higher Education Initiative

Recommend guidelines to higher education institutions for

- Including climate science and climate-friendly technologies (such as renewable energy development) in their curricula,
- Partnering with industries to transfer climate-friendly technologies from research to industries, and
- Applying climate-friendly measures (conservation and energy efficiency) on campuses.

Goals: High awareness of climate change and climate-friendly behavior in students, widespread institutional and student actions on conservation and energy efficiency, and measurable GHG emission reduction.

Timing: Complete the plan in 1 month, and complete the development of guidelines within another 4 months; deliver the guidelines to higher education institutions within 6 months of start.

Parties Involved: Statewide higher education institutions.

Implementation Mechanisms: Joining the American College & University Presidents Climate Commitment (ACUPCC) will satisfy the above goals. College and university presidents signing the Commitment are pledging to eliminate their campuses' GHG emissions over time, which involves

- Completing an emissions inventory;

- Within 2 years, setting a target date and interim milestones for becoming climate neutral;
- Taking immediate steps to reduce GHG emissions by choosing from a list of short-term actions;
- Integrating sustainability into the curriculum and making it part of the educational experience; and
- Making the action plan, inventory, and progress reports publicly available.

All the institutions within the University System of Maryland have agreed to join the ACUPCC. However, most private institutions and almost all community colleges are not members of ACUPCC yet. Establish a state goal for all higher education institutions in the state to join the ACUPCC within 6 months. Delegate early ACUPCC adopters like Frostburg State University and University of Maryland at Baltimore (UMBC) to coordinate a statewide effort to encourage all higher education institutions to join ACUPCC.

Cost: Not available at this time.

5. Public Media Initiative

Organize an annual 1-day conference for regional (Maryland and neighboring states) public media representatives on

- The state of climate change mitigation in Maryland and the level of attainment of state GHG reduction goals;
- Latest climate science and observations;
- Climate change impacts on public health, regional environment, the Chesapeake Bay, and the economy; and
- Applications of climate-friendly technologies.

Develop a Web site to host voluntary experts to answer climate-related questions from journalists.

Goals: Media information consistent with accepted climate science and latest technologies; high awareness in climate change and climate-friendly behavior in citizens.

Timing: Complete the plan in 1 month, and organize the first annual conference within 6 months.

Parties Involved: MDE and University of Maryland College of Education at College Park.

Implementation Mechanisms: Delegate the College of Journalism at College Park to plan and organize this annual conference. Invite authoritative panelists in climate science, climate impacts on public health, environment, industries, economy, renewable energy, and climate-friendly technologies. These experts can be tapped from institutions such as The Johns Hopkins University School of Public Health, Goddard Space Flight Center, National Oceanic and Atmospheric Administration, renewable energy industry, insurance companies, and the University of Maryland.

Cost: Not available at this time.

6. Commercial and Homeowners Initiative

Collaborate with county departments of environment and utilities to educate and stimulate commercial organizations (Chamber of Commerce, business owners, building industry, and building owners and tenants), apartment tenants, and homeowners to adopt climate-friendly measures and promote climate-friendly products. Deliver information (e.g., short seminars) on the climate crisis and call for citizens' actions in conservation and energy efficiency. Perform energy and environment audits of homes and buildings and provide specific recommendations for improvements such as

- Lighting, indoor temperature, insulation, and hot water temperature with measurable GHG emission reduction;
- Reducing paper consumption (e.g., by printing multiple slides on a page and using both sides of the paper);
- Reducing consumption of single-use containers (e.g., drinks in plastic bottles and cans); and
- Growing trees in place of lawns.

Goals: High awareness of climate change and climate-friendly behavior in these organizations; measurable GHG emission reduction.

Timing: Complete the plan in 1 month, and start implementation in 3 months.

Parties Involved: State and county departments of environment, utilities, and students.

Implementation Mechanisms: Collaborate with utilities to develop informational material and guidelines that target different audiences (e.g., commercial office buildings, homes, and apartments). Organize members of GREEN to conduct energy audits, demonstrations, and cost-saving analysis for business organizations, commercial buildings, and homes. Identify students to do community service projects.

Cost: Not available at this time.

7. Transportation Initiative

Educate and encourage transportation operators (buses, taxis, limousines, trucks, boats) to adopt climate-friendly measures such as

- Planning routes and avoiding traffic congestion using global positioning system (GPS) devices,
- Turning off the engine while waiting, and
- Using renewable fuels.

Goals: High awareness of climate change and climate-friendly behavior in transportation operators; measurable GHG emission reduction.

Timing: Complete the plan in 1 month, and start implementation in 3 months.

Parties Involved: State and county departments of transportation.

Implementation Mechanisms: Collaborate with transportation trade associations to develop informational material and guidelines that target different audiences (e.g., truck drivers and bus drivers). Organize members of GREEN to conduct demonstrations and cost-saving analysis.

Cost: Not available at this time.

8. Agriculture and Forestry Initiative

Develop and distribute guidelines to encourage farmers and forestry operators to practice climate-friendly measures. Develop a Web site to host voluntary experts to answer climate-related questions from this target audience.

Goals: High awareness in climate change and climate-friendly behavior in agriculture and forestry, measurable GHG emission reduction, carbon capture.

Timing: Complete the plan in 1 month, and start implementation in 3 months.

Parties Involved: State and county departments of agriculture, State Cooperative Extension.

Other: Not applicable.

Implementation Mechanisms

Collaborate with the Agricultural Cooperative Extension Office (at the University of Maryland at College Park) to develop and distribute climate-friendly guidelines.

Related Policies/Programs in Place

See above descriptions and note that education and outreach initiatives are also included with selected policy options of other TWGs.

Type(s) of GHG Reductions

Not applicable.

Estimated GHG Reductions and Net Costs or Cost Savings

Not applicable.

Key Uncertainties

None identified.

Additional Benefits and Costs

None identified at this time.

Feasibility Issues

Not applicable.

Status of Group Approval

Approved.

Level of Group Support

Unanimous.

Barriers to Consensus

None.

CC-6. Tax and Cap Policies

Assigned to Energy Supply Technical Work Group.

CC-7. Review Institutional Capacity to Address Climate Change Issues, Including Seeking Funding for Implementation of Climate Action Panel Recommendations

Policy Description

Addressing myriad challenges posed by climate change and implementing the numerous recommendations emanating from this process will be a long-term endeavor for the State of Maryland. To do this in a strategic and cost-effective way, it is important to review the state's capacity in areas such as finances, governance, authority, expertise, and technology.

Enactment of legislation and adoption of policies to mitigate GHG emissions is the essential first step for Maryland. Additionally, it is necessary that the State create the governance and organizational capacity to execute GHG mitigation policies, implement programs, monitor and analyze results, and modify and update policies and programs as necessary over time.

Additional agency resources will likely be required to implement some aspects of the Maryland climate protection strategies. The state needs to identify appropriate governance mechanisms, agency capabilities, staffing, and funding for effective implementation and enforcement of GHG mitigation programs. Financial mechanisms will also be needed to stimulate investment in developing cost-effective climate solutions.

Policy Design

Goals: The governance structure requires involvement at the highest levels of the Executive Branch. Agency organizational and staffing capacity must be adequate to oversee and carryout comprehensive GHG mitigation programs and activities. To this end, successful state institutional capacity might include the following elements:

- A member of the Governor's staff assigned as liaison for GHG policies.
- A department secretary assigned as the lead official for coordinating GHG mitigation. activities.
- A sub-cabinet committee for coordination of GHG programs and activities across departments and agencies.
- A departmental agency that is tasked with implementing key GHG mitigation programs and activities, serving as a coordinating point with respect to programs and activities housed in other agencies, analyzing and evaluating the overall effectiveness of GHG mitigation efforts, recommending changes and improvements to the efforts, and generally exercising primary responsibility for promoting successful GHG mitigation.
- Assignment of responsibility to all departments to consider GHG consequences when making decisions about departmental policies, programs, and activities.
- Full funding for the lead agency and all departments to carry out GHG responsibilities.
- An innovative state funding mechanism to stimulate investment in cost-effective climate change solutions.

- Identification of impediments that lenders place on financing climate-friendly projects.
- A research and development (R&D) program to address pertinent GHG technical issues in Maryland.
- Creation of institutional capacity and R&D efforts that remain in place to carry through to achievement of the 2050 goals.

Timing: 2008 and 2009.

Parties Involved: Governor's Office, General Assembly, MDE, and other Executive Departments and agencies within the state.

Other: In the office of every department secretary or agency head, a staff member must be assigned responsibility for ensuring that GHG mitigation objectives are integrated into the decision-making process of that department or agency.

The Department of Economic Development should be assigned responsibility for developing (for legislative enactment) a funding mechanism to stimulate investment in cost-effective climate change solutions.

Implementation Mechanisms

- The institutional capability should be created as soon as possible by Executive Order and by policy and budget legislation during 2008–2009.
- A supplemental budget should be introduced in the 2008 session of the General Assembly with a full funding request submitted for the FY 2009 budget cycle.
- Legislation should be enacted in 2008 and/or 2009.
- During 2008 the Maryland Department of Business and Economic Development (DBED) should develop cost-effective proposals for innovative financing programs such as the Revolving Loan Fund and loan guarantees. To assist in this effort, a public–private partnership process should be convened to analyze potential creative funding mechanisms. It should examine creative funding solutions such as using Regional Greenhouse Gas Initiative (RGGI) funds, aligning investors, financing up-front costs with out-year savings, creating incentives and other stimulus ideas, removing barriers and formulating financial policies that promote GHG reductions.

Related Policies/Programs in Place

Existing statutes and budgets.

Type(s) of GHG Reductions

Not applicable.

Estimated GHG Reductions and Net Costs or Cost Savings

Not applicable.

Key Uncertainties

Commitment of state officials to make funds available for all GHG reduction programs during a period of tight budget constraints. Support of citizens for funding all programs during a period when taxes have increased and other programs are subject to funding reductions.

Additional Benefits and Costs

None identified at this time.

Feasibility Issues

None identified.

Status of Group Approval

Approved.

Level of Group Support

Unanimous.

Barriers to Consensus

None.

CC-8. Participate in Regional, Multi-State and National GHG Reduction Efforts

Policy Description

Regional approaches undertaken in collaboration with partner states or other organizations can offer broader and more economically efficient opportunities to reduce GHG emissions across Maryland's economy. Maryland is already a member of the Northeast States RGGI. There are other options for broadening Maryland's regional, market-based GHG reduction strategies that should be considered, such as the Clean Cars Initiative.

The Governor and the Maryland General Assembly should aggressively push for federal action to reduce GHGs. Global warming is a problem that requires national and international action. An aggressive approach to GHG reductions within the United States would have a significant effect on the international reductions needed to begin reversing global warming trends. Ultimately, many of the climate protection issues need to be addressed at the national level, and Maryland needs to help shape those national initiatives.

Policy Design

First, work through the RGGI process to address CO_2 emissions from power plants, and then address GHG emissions from other sources.

Goals: Develop a regional cap-and-trade program for GHGs in the northeast.

Timing: June 2008 auctions and January 2009 RGGI start-up.

Parties Involved: Nine states in the RGGI.

Other: Not applicable

Implementation Mechanisms

Maryland is planning to participate in June 2008 RGGI auctions and is developing the regulations needed to do so.

Related Policies/Programs in Place

RGGI.

Type(s) of GHG Reductions

Not applicable.

Estimated GHG Reductions and Net Costs or Cost Savings

Not applicable.

Key Uncertainties

There are many unknowns about what types of federal programs will eventually be developed in 2009 and beyond.

Additional Benefits and Costs

It is acknowledged that regional efforts typically are more effective than individual states acting alone.

Feasibility Issues

Feasibility depends on the nature of future federal legislation or implementation of regional initiatives such as the RGGI.

Status of Group Approval

Approved.

Level of Group Support

Unanimous.

Barriers to Consensus

None.

CC-9. Promote Economic Development Opportunities Associated With Reducing GHG Emissions in Maryland

Policy Description

There are numerous economic and business opportunities that can arise from implementing a comprehensive GHG reduction strategy for Maryland. A variety of job creation possibilities are implicit in the MCCC recommendations for new approaches to transportation, land use, green construction, recycling and reuse, and energy-efficient products and services. The state should work with public and private entities to identify, promote, and finance these opportunities for economic development and job creation. The state should also work to keep existing green jobs in Maryland and prevent them from moving off-shore.

The growth of the "green industry" has the potential to benefit low- to mid-skill workers who can no longer depend on traditional manufacturing jobs. Since green jobs require applied technical skills, they generally pay decent wages. Unlike blue-collar jobs, many green-collar jobs require local employees and cannot be outsourced.

Another component of economic development is the promotion of buying locally produced foods and products. Consumer support for the local economy helps sustain Maryland businesses, jobs, and the tax base while reducing the consumption of fuel (and carbon dioxide emissions) in the transportation of foods and products over great distances.

Policy Design

Targeted business promotion and job creation should be a part of Maryland's effort to mitigate GHG emissions. Maryland should make every effort to establish itself as a leader in developing green industry.

In Maryland, job creation opportunities include designing and constructing green buildings; weatherizing existing buildings; retrofitting older buildings with energy efficient appliances and technologies; expanding the construction, maintenance, and operation of common-carrier and public transportation networks and systems; designing, constructing, and operating windmills, biomass generators, and solar collectors; and R&D on a wide array of new practices and technologies that can abate GHG production.

Promoting consumption of locally produced foods and goods will strengthen the Maryland economy.

Goals: By 2012 create 2,500 new jobs tied to green industry and energy efficiency.

Timing:
2008—Maryland DBED and task force develop recommendations.

2009 and 2010—Implementation of recommendations and delivery of training programs, financing mechanisms and loans to stimulate targeted businesses.

Parties Involved: Maryland DBED, county development offices, state and local chambers of commerce, labor unions, technical and trade schools, community colleges, Job Opportunities Task Force, Chesapeake Sustainable Business Alliance.

Implementation Mechanisms

Immediately, the Maryland DBED should be assigned responsibility for establishing a task force to identify and promote green industry opportunities, markets, and financing mechanisms. The task force should include economic development officials and representatives from business, industry, labor unions, think tanks, community colleges, and other institutions that offer job training. The task force should also include others with appropriate interest in and knowledge about labor and industry, energy efficiency and environmental conservation, skills development, and business finance and loan programs. The task force should promote use of public–private partnerships and should issue its initial report and recommendations by December 31, 2008.

Maryland DBED should also initiate staff activities to

- Emphasize a green-collar jobs component of employment development,
- Promote job training for green-collar jobs,
- Work with labor unions and technical schools to encourage green skills training,
- Identify new financing mechanisms and sources of seed money to stimulate and incubate green business development,
- Examine the potential for economic development opportunities of promoting energy efficiency,
- Promote consumer choice for foods and goods produced in Maryland,
- Identify what measures the state can take to promote greater R&D in the field and to attract green industries.

Related Policies/Programs in Place

Maryland and county economic development programs.

Type(s) of GHG Reductions

Not applicable.

Estimated GHG Reductions and Net Costs or Cost Savings

Not applicable.

Key Uncertainties

The speed with which businesses and consumers will adopt green practices.

Additional Benefits and Costs

Provides training to the green-collar work force. If selected industries are forced to move off-shore, then global GHG emissions may rise due to a lack of comparable controls outside the United States.

Feasibility Issues

Sources of funds to pay for job training programs.

Status of Group Approval

Approved.

Level of Group Support

Unanimous.

Barriers to Consensus

None.

CC-10. Create Capacity to Address Climate Change in an "After Peak Oil" Context

Policy Description

Oil is a finite resource, and many respected scientists and industry analysts project that we will reach the top of the bell curve of oil production—the "peak" of oil production—soon, if we have not already done so. Once we have passed the peak, termed *after peak oil,* oil will become ever more costly. This cost will be manifest in higher prices for a barrel of crude oil as well as in the higher environmental and health costs of extracting oil from nontraditional sources, such as tar sands, which require far more energy to extract and will result in even greater GHG emissions.

Because our society has been constructed to depend on an endless supply of inexpensive oil, the eventual lack of inexpensive oil will have profound impacts on all aspects of our society. In particular, GHG emissions could greatly increase as a result of society's reliance on the least expensive alternative to oil, which would be coal. Moreover, projections of GHG emissions over time have generally not factored in the increased emissions from the use of more coal or the increased emissions from the use of nontraditional fossil fuels as the demand for energy outstrips the supply of oil.

Any hope of successfully achieving the state's GHG emission reduction goals will depend on effectively avoiding the easy energy shortage solutions of relying on more coal or encouraging the use of nontraditional fossil fuels.

Maryland should take a strategically proactive stance to deal with after peak oil by establishing a State After Peak Oil Advisory Council of experts and stakeholders to review and evaluate all proposed climate change and energy-related policies and legislation for their appropriateness and sensibility in the context of shrinking supplies of affordable oil.

Policy Design

Goals: By 2010, the State of Maryland will have an After Peak Oil Advisory Council that reviews and evaluates all proposed climate change and energy-related policies and legislation. The recommendations of the Council should be considered and concerns should be addressed before the proposed policy or legislation moves forward.

Timing: By 2009, the Governor will appoint a core group of Council members representing major stakeholders and content experts. Additional Council members will be recruited by a nonpolitical process. By 2010, the Council will have finalized their mechanism of operation.

Parties Involved: All state agencies, energy producers, consumers, environmentalists, and health professionals.

Other: Examine both short-term and long-term aspects of this challenge.

Implementation Mechanisms

Create the Advisory Committee and make it operational.

Related Policies/Programs in Place

None.

Type(s) of GHG Reductions

Not applicable.

Estimated GHG Reductions and Net Costs or Cost Savings

Not applicable.

Key Uncertainties

The timing of peak oil and the rate of decline once peak oil has been reached are uncertainties.

The rate of change and the price of the remaining supplies of oil will depend on many factors, including global demand, stability of certain geopolitical regions that currently have oil supplies, development of new technologies, and other factors that the state will have little control over. However, planning now for how to handle these events will help the state determine reasonable alternatives. There will be uncertainties associated with the currency exchange as it relates to the value of the dollar.

Additional Benefits and Costs

None identified at this time.

Feasibility Issues

No barriers to feasibility except an initial need to explain the situation and the need for planning and action on a topic that is not well known or understood by many.

Status of Group Approval

Approved.

Level of Group Support

Unanimous.

Barriers to Consensus

None.

CC-11. Evaluate Climate Change Policy Options to Determine Projected Public Health Risks/Costs/ Benefits

Policy Description

Climate change will have profound and largely negative effects on the health of Maryland's citizens. Dealing with these negative effects will be costly in terms of actual dollars spent for health care by state government, private businesses, and individuals; increased burden of disease on individuals; time off work and out of school; and lost productive years of life. However, many strategies for reducing GHG emissions have beneficial effects on health, such as improved air quality.

Because the potential risks to health of unmitigated climate change are so extreme and the potential benefits to health of certain policies to reduce GHG emissions are significant, these risks, costs, and benefits should be considered for all climate change and energy policies. It is also conceivable that policies to reduce GHGs could have unintended negative side effects on health.

To ensure that these risks, costs, and benefits are evaluated in a systematic manner, Maryland should establish a State Climate Change Environmental Health and Protection Advisory Council of content experts and stakeholders to review all climate change and energy-related policies and legislation for health benefits and risks to all Maryland's citizens. Careful attention should be given to vulnerable populations such as children and older people.

Policy Design

Goals: By 2010, Maryland will have a State Climate Change Environmental Health and Protection Advisory Council to review and evaluate all proposed climate change and energy-related policies and legislation. The recommendations of the Council should be considered and concerns should be addressed before the proposed policy or legislation moves forward.

Timing: By 2009, the Governor will appoint a core group of Council members representing major stakeholders and content experts. Additional Council members will be recruited by a nonpolitical process. By 2010, the Council will have finalized their mechanism of operation.

Parties Involved: All state agencies, energy producers, consumers, environmentalists, and health professionals.

Other: Note that the Maryland Adaptation process is also addressing public health–related issues associated with climate change.

Implementation Mechanisms

Create the Advisory Council and make it operational.

Related Policies/Programs in Place

Public health is also being addressed in the Adaptation process.

Type(s) of GHG Reductions

Not applicable.

Estimated GHG Reductions and Net Costs or Cost Savings

Not applicable.

Key Uncertainties

There are many uncertainties regarding the health effects of climate change. Forming an Advisory Group that is charged with exploring data as they become available and using its collective expertise to protect the public's health will likely improve outcomes.

Additional Benefits and Costs

None identified at this time.

Feasibility Issues

No barriers to feasibility.

Status of Group Approval

Approved.

Level of Group Support

Unanimous.

Barriers to Consensus

None.

Acronyms and Abbreviations

ACUPCC	American College & University Presidents Climate Commitment
CC	Cross-Cutting Issues [TWG]
CO_2	carbon dioxide
DBED	[Maryland] Department of Business and Economic Development
FTE	full-time equivalent
GHG	greenhouse gas
GPS	global positioning system
GREEN	Governor's Regional Environmental Education Network
IPCC	International Panel on Climate Change
MCCC	Maryland Commission on Climate Change
MDE	Maryland Department of the Environment
$MMtCO_2e$	million metric tons of carbon dioxide equivalent
MSDE	Maryland State Department of Education
R&D	research and development
RGGI	Regional Greenhouse Gas Initiative
RMAN	Recovered Materials Advisory Notices
TWG	Technical Work Group
UMBC	University of Maryland at Baltimore

Units of Measure

$\$/tCO_2e$	dollars per metric ton of carbon dioxide equivalent

Appendix E

Maryland Climate Action Plan

Adaptation & Response Working Group

Policy Option Documents

Contents

Existing Built Environment Infrastructure

EBEI-2. Observation Systems for Changes in Coastal Areas

Option Description

The Chesapeake Bay is the largest inner-coastal estuary in the nation. It covers more than 166,000 square kilometers, has more than 150 rivers and streams draining into the watershed, and is home to about 15 million people. Most of Maryland's communities and economic activities in this low-lying coastal region are particularly vulnerable to storm surges and flooding, events that will be likely be intensified by the rising sea level associated with climate change. Maryland relies on its coastal areas along the Chesapeake Bay and its Atlantic coast for healthy fisheries and reliable transport and navigation. Its dependence on infrastructure networks (e.g., roads and power grids) intensifies the potential vulnerability of these areas to impacts from climate change–induced natural disasters.

Enhanced ability to observe changes along Maryland's coastal areas induced by sea level rise (SLR) will provide key benefits to the state. Under climate change, managing resources in these areas is more important that ever and will require accurate information from integrated observation systems to allow for detection and prediction of the causes and consequences of changes in coastal systems, watersheds, and infrastructure resources. This option will support, enhance, and integrate observation systems already in place in Maryland. Specifically, the option will strengthen those systems to enable comprehensive surveillance, monitoring, documentation, and dissemination of rates and locations of SLR in Maryland. Surveillance equipment will be installed in coastal sites where current public–private infrastructure is potentially vulnerable to small increases in sea level, long-term coastal monitoring aspects will be incorporated into existing protocols, and observation activities will be incorporated into regional efforts.

Option Design

This policy option aims to enhance statewide monitoring programs in natural and urban settings to detect biological, physical, and chemical changes and responses due to direct and indirect effects of climate change. This option will be facilitated through the observation, analysis, and interpretation of trends in coastal water levels, elevation (subsidence rates, if any), shoreline change, wetland loss, and tidal influence on estuaries and water supplies. The observation systems will enable the state to assess the responses of coastal landforms to SLR and to the effects of increases in storm activity. Implementation of the policy option will be coordinated with Policy Option FBEI-6, Integrated Geographic Information Systems: Mapping, Modeling, and Monitoring (Appendix F) and with the policy options related to detecting specific impacts of climate change and SLR on resources and resource-based industries.

The specific objective of this option is to assess how existing observation systems for the Chesapeake Bay region can be enhanced to better understand and address long-term SLR and its impacts on the built environment. The overall option design is summarized in the bullets below.

Targets: Observation networks are an essential component of adaptive management in low-lying coastal areas. They are also essential in planning and evaluating the effectiveness of restoration programs in Maryland's coastal zone. The target for this option is in the form of a detailed assessment regarding the adequacy of Maryland's current observation systems, system protocols, technologies, and surveillance strategies to address long-term changes in SLR and the associated impacts. The output of the study should be a series of recommendations regarding how current observation networks could be reinforced and how new components could be added to better address changing conditions regarding SLR. The following components should be part of the study:

- Enhance local-, state-, regional-, and federal-level interagency integration and coordination of observation systems that detect trends in coastal water levels, elevation (subsidence rates, if any), shoreline change, wetland loss, and tidal influence on estuaries and water supplies.
- Assess the suitability of vertically controlled tide gauges.
- Investigate funding the installation of additional tide gauges in particular locations, including Jug Bay.
- Assess the adequacy of surface elevation tables (SETs) to measure whether marsh accretion is keeping pace with erosion or inundation and examine opportunities to add more SETs for select marsh locations.
- Integrate findings and study objectives for the Statewide Wetlands Monitory Strategy, currently under development by the Maryland Department of the Environment (MDE).
- Observe and record changes for a set of "leading indicators" of specific climate change impacts. Include indicators that are representative of specific geographic ranges or behaviors or population characteristics of certain species of plants, birds, mammals, and insects that are known to be hypersensitive to SLR and other climatic changes.
- Encourage the use of the Maryland Geological Survey Groundwater Quality Network to assess well water quality in areas where saline intrusion adjacent to tidal waters is known to occur.
- Evaluate whether the Maryland Geological Survey Subsidence Studies Program needs to be expanded to assess the risk of elevation declines due to ground water withdrawals, which would exacerbate any impacts of SLR. Locations to be assessed could include those with significant current ground water withdrawals and/or those where population and associated groundwater withdrawals are projected to increase significantly in the near future.

Timing: The timing of the study is immediate. It is anticipated that a 3-year period will be needed to complete the study. By the end of this period, there should be a detailed recommended program regarding additional integrated observations that are required, supplemental data management and distribution systems (if any), and a set of analytical products that respond to the specific needs of the commercial, management, recreational, educational, scientific, regulatory, safety, hazard protection, and restoration communities.

Parties Involved: Several parties would be involved in the design and oversight of the study. At the state level would be the Maryland Department of Natural Resources (DNR), MDE, and local and national weather services offices. At the regional and national levels would be the National

Oceanic and Atmospheric Administration (NOAA), National Geodetic Survey (NGS), Chesapeake Bay Observing System (CBOS), the United States Geological Survey, and the National Office for Integrated and Sustained Ocean Observations.

Implementation Mechanisms

This option would be implemented by first preparing a feasibility study on the scope, issues, challenges, and likely costs associated with upgrading existing observation systems. On the basis of this study, terms of reference for the assessment would be prepared and implemented by a qualified organization or consortium. The recommendations of the study would become the input for changes to existing rules and regulations or new legislation to implement the activities necessary to adequately monitor SLR and the effectiveness of Maryland's adaptation responses to climate change.

Related Policies/Programs in Place

Chesapeake Bay Observing System (CBOS): There are important observation systems already in place in Maryland to monitor the Chesapeake Bay. The CBOS is an organization that provides integrated data observation, management, and distribution systems and information for use by those concerned about the Chesapeake Bay and by residents of coastal communities. It is part of an evolving subregional observing system embedded in the Mid-Atlantic Coastal Ocean Observing Regional Association (MACOORA) and the congressionally mandated Integrated Ocean Observing System (IOOS).

Center for Operational Oceanographic Products and Services (CO-OPS), Tides and Currents: Tides and Currents, managed by CO-OPS, is the portal to NOAA's collection of oceanographic and meteorological data (historical and real-time), predictions, and nowcasts and forecasts. Historic tide gauge data for the Chesapeake Bay can be found at http://tidesandcurrents.noaa.gov/index.shtml

National Water Level Observation Network (NWLON): NWLON is a network of 200 long-term, continuously operating water-level stations throughout the Unites States that provide tidal data and water level observations as well as long-term sea level trends. They also serve as the foundation reference stations for NOAA's tide prediction products, and they serve as controls in determining tidal data for all short-term water-level stations.

VDatum: VDatum is a software tool administered by NOAA that is designed to coordinate data transfer between 28 different vertical datums consisting of tidal, orthometric, and ellipsoidal datums (http://www.nauticalcharts.noaa.gov/csdl/vdatum.htm).

Climate Change Science Program (CCSP): The CCSP Draft for Synthesis and Assessment Product 4.1 is titled "Coastal Elevations and Sensitivity to Sea Level Rise" and is available for public comment at http://www.climatescience.gov/Library/sap/sap4-1/public-review-draft/

National Geodetic Survey (NGS): NOAA's NGS defines and manages a national coordinate system. This network, the National Spatial Reference System (NSRS), provides the foundation for transportation and communication, mapping and charting, and a multitude of scientific and engineering applications. The following are related programs:

- *Continuously Operating Reference Stations (CORS)*—The CORS network includes more than 1,200 global positioning system (GPS) stations that run 24 hours a day, 7 days a week and are adjusted daily. The CORS system enables positioning accuracies that approach a few centimeters relative to the NSRS, both horizontally and vertically. The NGS is working with CO-OPS to co-locate CORS with NWLON stations. This has already been done at several coastal sites, including Charleston, South Carolina, and Key West, Florida. Co-locating CORS with NWLON stations enables local land elevation changes to be accounted for within local sea level measurements.
- *Height Modernization Program (HMP)*—The HMP provides accurate height information by integrating GPS technology with existing survey techniques.
- *Remote Sensing Division (RSD)*—The RSD is responsible for collecting national shoreline information to be fed into nautical charts.
- *State Geodetic Advisors*—Geodesists are placed within states to help with surveying and geospatial data issues.
- *Surface Elevation Tables (SETs)*—NGS is currently working on guidance documents on how to use GPS to tie SETs to local tidal and geodetic datums to enable measurement of vertical movement of coastal habitats.

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TEA/MANTA [Tidewater Ecosystem Assessment/Monitoring and Non-Tidal Assessment] Tidal Monitoring—Maryland's Chesapeake Bay Water Quality Monitoring Program includes an integrated set of components that together provide a comprehensive assessment of water quality conditions. This set of water quality and habitat indicators includes physical and chemical properties, nutrient limitation of algal growth, ecosystem processes, river inputs of nutrients and sediments, phytoplankton, zooplankton, and benthic organisms. The design, analysis, and interpretation of each component of the program address four objectives: (1) characterizing existing conditions; (2) detecting changes and trends in key water quality variables in response to management actions; (3) determining attainment or non-attainment of water quality criteria; and (4) understanding how the Bay ecosystem functions as it relates to anthropogenic and natural stresses, management actions, and relationships between water quality and living resources. Data are physically collected by scientists 16 times a year at 22 stations located in Maryland's Chesapeake Bay mainstem, 12 to 20 times a year at 55 stations sampled in the Chesapeake Bay tidal tributaries, and 12 times a year at 45 stations in the Coastal Bays.

TEA/MANTA/ Non-Tidal Monitoring—Long-term water quality monitoring has occurred at 54 locations on major (4th order and larger) non-tidal portions of Maryland's rivers since 1976. Sampling at these stations provides the data for determining trends in water quality constituents commonly associated with urban and agricultural land use. Some of the TEA/MANTA monitoring data mentioned above can be accessed via Eyes on the Bay (EOTB).

Eyes on the Bay (EOTB)—EOTB (a Web site of DNR's TEA Division) provides easy access to near real-time, mapped, and historical Chesapeake and Coastal Bays water quality information and data on water temperature, salinity, dissolved oxygen (the amount of oxygen available for aquatic life), water clarity, chlorophyll (the amount of algae in the water), and pH levels (the acidity or alkalinity of the water). Continuous Monitoring and Water Quality Mapping data can be retrieved at EOTB.

MANTA–Maryland Biological Stream Survey (MBSS)—Since 1994, the Maryland DNR MANTA has sampled and assessed more than 2,000 freshwater wadable streams for biological, habitat, and chemical quality through the MBSS. Stream quality indicators have been developed for fish, benthic macro-invertebrates, and salamanders and for their physical habitat. MBSS results have been used for (1) watershed characterizations (i.e., targeting areas in need of both restoration and protection) via the Clean Water Action Plan and the resultant Watershed Restoration Action Strategies, (2) listing impaired streams for MDE's 303(d) list, (3) evaluating stressors to aquatic fauna, and (4) determining geographic ranges of rare, threatened, or endangered aquatic species.

MANTA's Sentinel Site Network—To track natural variability in stream chemical, physical, and biological conditions, the MBSS established a long-term monitoring component, the Sentinel Site Network, in 2000. The Network consists of 26 of the highest quality, minimally disturbed streams in Maryland that were selected on the basis of physical, chemical, and biological data collected by the MBSS from 1995 to 1997. Long-term monitoring of sentinel sites offers the best hope for detecting the effects of climate change on Maryland's non-tidal streams and rivers and will provide important information for the management of stream resources in the face of this threat. In addition, MANTA has developed a proposed monitoring program for tidal freshwater ecosystems because there is a paucity of information on these unique transitional habitats.

Comprehensive Shoreline Inventory (CSI)—Maryland's Coastal Program contracted with the Virginia Institute of Marine Sciences (VIMS) to prepare a CSI that captures baseline shoreline conditions throughout the tidal portions of Maryland's coastal counties. Shoreline features and conditions were identified by using a three-tiered shoreline assessment approach. The Inventory divided the shore zone into three regions: (1) immediate riparian zone (land use), (2) bank (bank characteristics such as height, bank type, and shoreline buffers), and (3) shoreline features (shoreline attributes such as bulkheads, riprap, marinas, boat ramps, and docks). Data from the inventory were processed to create three geographic information system (GIS) coverages displayed in reports, summary tables, and maps that are viewable online at http://ccrm.vims.edu/index.html. CSI is often used to determine changes in shoreline conditions due to climate change and SLR impacts. The CSI has already been used by St. Mary's County to conduct a shoreline structure damage assessment following Tropical Storm Isabel. The CSI was incorporated into Hazards U.S. Multi-Hazard (HAZUS-MH) to provide shoreline conditions for conducting the Level One analysis of flood vulnerability in Maryland. In addition, the CSI was merged with the Stream Corridor Assessment used in the development of the Watershed Restoration Action Strategy (WRAS) program to provide a watershed view of the tidal and non-tidal shoreline conditions. The CSI information was used in conjunction with historical shoreline position data by the Maryland Geological Survey to assess loading of sediments to the Chesapeake Bay from shore erosion. Changes in shore erosion rates and sediment loading that accompany accelerating SLR can be assessed from this database.

Maryland Geological Survey Groundwater Quality Network—DNR's Maryland Geological Survey routinely conducts well water quality assessments in areas where saline intrusion adjacent to tidal waters is known to occur. Currently, wells on Kent Island and in Ocean City are sampled annually, Annapolis Neck less frequently, and Indian Head on the Potomac River only occasionally. Groundwater is the major source of potable water in the rapidly developing tidewater region of the state, and the combination of increased extraction for human consumption and SLR are likely to increase the areas where saline water intrudes into aquifers and increase the salinity of the water where intrusion is currently known to occur. The database for areas already under study and the methodologies currently in use can be extended to other areas at risk of saline intrusion.

Maryland Geological Survey Subsidence Studies—The Maryland Geological Survey, in cooperation with Anne Arundel County and the State Highway Administration, has been conducting elevation surveys at three county water supply well-fields since 1994. These surveys have indicated only minor declines in elevation at the locations of the withdrawals, but groundwater levels at these sites have not declined significantly to date. This methodology can be extended to other locations that might be at risk of elevation declines due to groundwater withdrawals, which would exacerbate any impacts of SLR. Locations to be assessed could include those with significant current groundwater withdrawals and/or those where population and associated groundwater withdrawals are projected to increase significantly in the near future.

Additional Benefits and Costs

Implementing a program for enhancing statewide monitoring programs to detect the direct and indirect effects of climate change will be subject to a variety of costs and produce distinct benefits. As noted above, there are already several related programs/policies in place into which a climate change observational system can be integrated. The types of costs considered here are incremental to those that have already been incurred to develop and maintain the existing framework of observation systems currently in place in Maryland to monitor the Chesapeake Bay.

Incremental costs to address climate change through enhanced monitoring programs fall into four major categories: assessment, equipment, staffing, and maintenance. Assessment involves the costs for designing and carrying out the feasibility study on the upgrading of existing observation systems. Equipment costs involve the costs associated with any new equipment (e.g., gauges), software (e.g., database management), and any departmental/office arrangements that are implemented on the basis of results of the feasibility study. There may also be new staffing costs associated with recruiting additional technical expertise to manage the observational networks and produce information specifically tailored to climate change. Finally, there will likely be a set of annual costs associated with the maintenance of physical equipment and database systems.

The benefits associated with enhanced monitoring programs in Maryland center on the degree to which they can enhance both the state's adaptive capacity and its flexibility to respond to future climate change threats. Regarding adaptive capacity, the enhanced observational networks—and the additional time series data they will provide—should strengthen the ability of institutions and systems in Maryland to better foresee looming risks and plan for future climate change damages. These benefits, while difficult to quantify, are nevertheless substantial. Regarding flexibility, the accumulation and processing of information associated with the operation of the observation networks will increase the state's flexibility for adapting to future possible responses to an uncertain and changing climatic regime. The option will thus enhance the ability of the state to consider and adopt future corrective measures as needed, including statutory changes. Taken together, the value of the adaptive capacity and flexibility benefits is likely to be much higher than the incremental costs associated with the implementation of the option.

Feasibility Issues

None.

Status of Group Approval

Unanimous

Barriers to Consensus

None.

EBEI-3. Adaptation of Vulnerable Public and Private Sector Infrastructure

Option Description

Maryland has thousands of miles of developed waterfront property along the Chesapeake Bay and its tributaries. Much of this area contains public and private sector infrastructure that will be adversely impacted by SLR and increased climatic severity (storms and wind-driven tides) caused by climate change and subsidence. Public sector infrastructure (i.e., roads, bridges, airports, wastewater treatment facilities, and municipal water systems) is essential for community framework. Private sector infrastructure (i.e., residential properties, boating facilities, retail and office buildings, and farms) has historically enjoyed higher market value compared with inland properties because of its proximity to the water, especially in more recent times.

As the sea level continues to rise, both state and local governments in Maryland, as well as many other public and private property owners are facing the very real and hard decisions about how to adapt and at what expense. Decisions about how to adapt to the impacts of SLR will be different for different types of land use, and must take into consideration the value of the land (monetary, resource-value, and perceived value), public opinion, public safety and risk assessments, ecosystem survival and replacement, and environmental and development opportunities.

There are potential adaptation options—protection, relocation, and retrofitting—that can be used to respond to SLR. Vulnerable coastal infrastructure can be protected by using structural bulkheads, seawalls, or revetments (the least desirable means). Some forms of protection can improve ecosystems and create new opportunities. However, it will not be practical (socially, economically, or environmentally) to use protection for all areas at risk. A framework for making abandon/modify/move/protect decisions must be developed in combination with other comprehensive planning and emergency management decision-making frameworks.

The objectives of this option are to identify and assess Maryland's SLR-impacted public and private sector infrastructure (based on various SLR scenarios agreed upon by the Scientific and Technical Work Group [STWG] that identified vulnerable inundation areas), categorize and assess impacted infrastructure on the basis of research that determines feasible option strategies, and formulate strategies to integrate action plans at the local, state, and federal levels.

In order to plan and to ascertain priorities, properties that can adapt to SLR need to be differentiated from those that may need to be abandoned and/or relocated. For public infrastructure, this determination can be made by comparing the impact of projected SLR and the projected useful life of the facility. Coordinated plans need to be developed between the private sector and local, state, and federal authorities for how adaptation can best be accomplished. Existing laws and regulations, processes, and practices need to be revisited and possibly changed, eliminated, and/or supplemented so that they facilitate positive potential results from adaptation in recognition of the changing climate and environment.

Maryland county topographic storm and tidal surge mapping should also include all active freight and passenger railroad lines and their potential susceptibility to storm surges and rising sea levels. This would include all Class I (CSX and Norfolk Southern) and short-line freight railroads and all transit rail operators such as AMTRAK and MARC. MARC passenger trains operate on either CSX or AMTRAK's infrastructure; therefore, all SLR planning efforts must include coordination of each of their planning and investment efforts to address adaptive response issues. As the sea level rises, railroads across lowlands near tidal water will experience more frequent flooding during high tides and storms. This effect may be especially severe in certain estuaries where the rise in sea level will be amplified, the more so because these same estuaries are more vulnerable to storm surges as water funnels into a gradually narrowing arm of the sea.

It is most important that every effort be made to encourage and facilitate opportunities to offset the impact of inevitable losses.

Option Design

Targets: The following are the key targets for this option:

- Raise awareness of the impact of SLR in potentially impacted areas. Since SLR is so gradual, one of the obstacles to implementing successful adaptation strategies will be to overcome denial and achieve "buy-in" and participation from stakeholders.
- Identify vulnerable SLR inundation areas along Maryland's shoreline by using newly acquired topographic data.
- Assess public and private sector infrastructure within these vulnerable areas to gain a statewide sense of the breadth of infrastructure impacted.
- Categorize and assess impacted infrastructure on the basis of research to determine feasible adaptation strategies. Research should be conducted by a team of experts who consider the successes and failures of other actions attempted or contemplated worldwide, potential engineering solutions, and technological applications to determine potential applicability to the projected impacted areas. The scope of this study should be to prepare descriptions of generic adaptation methods and assess the feasibility (costs and impacts) of implementing various adaptation scenarios (abandon/modify/move/protect).
- Formulate and prioritize strategies to adapt to climate changes and SLR and create a method for integrating action plans at the state and local levels This should begin as soon as categorization and assessment are completed during 2010 or 2011.
- Formulate and prioritize strategies for adapting railroads to climate change and include the following components:
    - *Track*—The levels of such railroads may have to be raised by <u>reballasting</u> from time to time. Some railroads already experience flooding during heavy rains and high tides, and these events would increase. Especially in the case of short-line railroads, tracks may be so low that they are often flooded, and the beds may be vulnerable to sinking from compaction of marsh peat. A number of East Coast railroads have been in their current locations for 150 years, and many tracks, signals, and stations are low enough to be flooded during severe storms.
    - *Bridges*—All Maryland-owned railroad bridges come under the same safety guidelines as SHA highway bridges. Bridge clearance above high water will gradually diminish for bridges across water in the tidal zone. The amount of the reduction will be greater in the

case of bridges upstream in estuaries where the rise of water level is amplified by funnel effects. Although the rise may be slow and gradual, the consequences of damage to a bridge may be so catastrophic as to warrant regular monitoring.

  - *Tunnels*—Tunnels may also become more vulnerable, because the risk of their entrances and vents flooding will be greater and because the hydraulic pressure on the tunnel walls increases as water tables rise. There are no state-owned railroad tunnels. The Howard Street Tunnel in Baltimore City is owned and maintained by CSX Transportation, and the B&P and Union Tunnels in Baltimore City are owned and maintained by AMTRAK. Planning and investment for SLR issues by these carriers must be coordinated to address adaptive response issues.

Timing: The following are some of the key schedule milestones for this option:

- Raising the awareness level has already begun and is an important part of all options in this effort.
- Existing tools, programs, and resources could be used to compile data on projected SLR inundation areas and existing infrastructure within those areas and therefore could begin immediately and be targeted for completion by the end of 2009.
- Impacted infrastructure should be categorized and assessed after the initial data compilation. This phase of the option should begin in late 2009 and be completed by 2011.
- Formulate strategies, priorities, and implementation action plans.

Parties Involved: Coordinated involvement will be needed from property owners, local town and city governments, county governments, and Maryland agencies, including DNR, Maryland Department of Transportation (MDOT), MDE, Maryland Department of Planning (MDP), and the Maryland Utilities Commission. Federal agencies that need to be involved include the U.S. Department of Agriculture (USDA) and the U.S. Army Corps of Engineers (USACE).

Implementation Mechanisms

Identifying and assessing impacted properties, performing research, determining strategies, creating incentives, and enabling legislation and/or changes in processes and practices are needed before widespread adaptive measures can be successfully implemented.

Related Policies/Programs in Place

The following are related policies/programs in place in Maryland:

- **Comprehensive Shoreline Inventory (CSI):** [Described in detail under EBEI-2, Policies/Related Programs in Place.] The CSI can be used as a state and local planning tool to inventory and assess coastal infrastructure vulnerable to SLR inundation or coastal flooding.
- **Strategic Shore Erosion Assessment (SSEA):** From 2000 to 2002, a NOAA Coastal Services Center Coastal Management Fellow worked with the Coastal Program to develop a comprehensive approach to shore erosion planning for Maryland and to develop a protocol for creating regional strategies to deal with shoreline erosion issues. The Fellow worked closely with Dorchester and St. Mary's counties to identify an approach that would balance

the need to address risk from erosion while also maintaining natural shoreline habitat. The resulting protocol became the foundation for the SSEA, currently under development.

In 2002, Coastal Program staff worked with DNR's Shore Erosion Control Program to integrate the protocol developed for the SSEA into the Program's Project Selection Criteria and Financial Assistance Priority Rating System. Environmental and habitat enhancement considerations are now incorporated into the rating system, which creates a score for homeowner projects based on criteria such as infrastructure threat from erosion and an applicant's financial need.

- **Maryland's 2006–2010 Coastal Zone Management Act (CZMA) §309 Coastal Hazard Strategy:** The Strategy, approved by NOAA in 2006, defines the current work plan for developing the SSEA. The project is being implemented in four phases: (1) generation of the fetch exposure tool, community risk assessment, and environmental risk assessment; (2) application and validation of GIS tools through development of the Corps Feasibility Study Master Plan; (3) incorporation into the interactive mapping application; and (4) workshop development and training of state and local coastal managers and planners.
- **Chesapeake Bay Shore Erosion Control Master Plan:** Maryland's Coastal Program is currently participating in the development of the Chesapeake Bay Shore Erosion Control Master Plan along with the USACE and MDE. The Plan, which is being developed as a component of Chesapeake Bay Coastal Management Feasibility Study, will result in outreach material for contractors and homeowners as well as a Master Plan that uses modeling tools to evaluate stretches of shoreline and prioritizes these areas for erosion control activities. The Master Plan will serve as a guide for potential shore erosion management strategies and will help the agencies maintain consistency when promoting strategies along tidal shorelines. These strategies will likely include structural and non-structural erosion control devices, designation of natural erosion areas, land acquisition, and establishment of local erosion-based setback requirements.
- **Draft Report 4.1 of the U.S. Climate Change Science Program (CCSP) Synthesis and Assessment Product: "**Coastal Elevations and Sensitivity to Sea Level Rise" is one of 21 synthesis and assessment products being prepared by CCSP (www.climatescience.gov/Library/sap/sap4-1/public-review-draft/). The report went out for public review and comments were due by COB April 10, 2008. The draft report includes the results of a research project titled "The Likelihood of Shore Protection in Maryland." This project, conducted by the U.S. Environmental Protection Agency (EPA), was based on interviews with state regulators and county planners and was intended to investigate existing and anticipated coastal policies and land uses. The study developed maps that distinguish coastal areas in Maryland that are likely to be protected as the sea level rises and areas that will likely retreat because of protection cost or current land use policy.
- **HAZUS-Multi Hazard (HAZUS-MH):** HAZUS is a risk assessment software program for analyzing potential losses from floods, hurricane winds, and earthquakes. HAZUS-MH can be used to estimate damage before or after a disaster occurs and takes into account social and economic impacts of a hazard event. MDE began working with Salisbury University in 2004 to complete a statewide analysis of flood vulnerability estimated with the HAZUS-MH flood module. The Level One analysis, completed in June 2005, estimates flood damage to commercial and residential properties from a 100-year coastal or riverine flood event. This

study takes the next step from identifying flood vulnerability to understanding the risk to the built environment. The final report, "An Assessment of Maryland's Vulnerability to Flood Damage," is now available at: http://www.esrgc.org/pdf/hazus/An%20Assessment%20of%20Maryland's%20Vulnerability%20to%20Flooding.pdf. Moreover, the coordination and reinforcement for this option should be coordinated with the other options in this report:

- Assessment of Coastal Zone Adaptation Options and Evaluation of Shoreline Protection Structures (RRI-7, RRI-9, and EBEI-6)
- Integrated Planning for Coastal Erosion, Coastal Storms, and Sea Level Rise (FBEI-1)
- State Agency Reporting on Response to CCC Findings (FBEI-2)
- Preserve Undeveloped, Vulnerable Lands (RRI-7, RRI-9, EBEI-6)
- Integrated Geographic Information Systems: Mapping, Modeling, and Monitoring (FBEI-6)
- New Criteria for Identifying Priority Protection Areas (RRI-1)
- Forest and Wetland Protection (RRI-4, RRI-11)
- Modify Environmental Protection Regulations to Promote Sustainable Shoreline and Buffer Area Management Practices (RRI-7, RRI-9, EBEI-6)

Estimation of Adaptation Benefits and Costs

Implementing a program for the adaptation of vulnerable public and private sector infrastructure will undoubtedly have tremendous costs to local, state, and federal government and the private sector. Much of this cost can be offset by implementing laws, regulations, and policies that encourage innovative, environmentally sound, practical solutions even though some of these will require a new paradigm regarding adaptation. Cost considerations include the following:

- Estimated detailed cost of adapting, relocating, and replacing public infrastructure can be determined only after impacted properties have been identified and assessed. Some properties, particularly major infrastructure, will be able to serve out their useful life before they need to be replaced. In the meantime, care should be taken to not site new public sector infrastructure in impacted areas. However, there will be a considerable financial cost to local, state, and federal governments from replacing or relocating impacted public infrastructure that becomes inundated prior to fulfilling its projected useful life. This contrasts with the current perception that the life spans of certain properties can often be extended by renovation or modernization, which may be more cost-effective than relocation and replacement.
- Abandonment of properties will result in loss of asset value and thus loss of tax revenues for local and state governments.
- Environmental and ecological costs will result from the fact that currently existing, productive, useful farmland and marshes will be eliminated as SLR progresses.
- Benefits and opportunities will accrue from several sources including protecting existing properties where practical and feasible by facilitating an environment that encourages innovation to maintain or improve value while maintaining or improving environmental and ecological sensitivity.

- Innovative incentives should be made available to the private sector to stimulate opportunities to help offset asset losses when appropriate.
- The following are data sources that are relevant to the assessment of costs and potential benefits of this option:
  - Town of Oxford, Maryland Flood Insurance Rate Map, Community panel number 240068-001 A, effective September 28, 1984.
  - Earth From Space, available at: http://earthfromspace.photoglobe.info/spc_netherlands_dikes.html
  - The Tyee, available at: http://thetyee.ca/News/2007/05/28/FloodControl/
  - MSN Encarta, available at: http://encarta.msn.com/encyclopedia_761572410/netherlands_the.html
  - Maryland Shorelines Online, available at: http://shorelines.dnr.state.md.us/living.asp
  - Chesapeake Bay Funders Network, available at: http://www.campbellfoundation.com/html/related_projects.html
  - Coastal defense solutions (approach of ComCoast) http://www.comcoast.org/
  - Intergovernmental Panel on Climate Change, available at: http://www.ipcc-wg2.org/index.html

Feasibility Issues

The feasibility of the strategies and priorities identified from research efforts depends on accurate projections of SLR, as well as the availability of adequate funding for strategies that can be justified on the basis of short-term and long-term ecological, environmental, and financial benefit.

Uncertainties that affect the feasibility of this option are (1) the rate and extent of SLR and the relative impact of subsidence, (2) property protection across multiple owners if one or more do not wish to participate, and (3) the nature of the future federal response to the threat of SLR.

Status of Group Approval

Unanimous

Barriers to Consensus

None.

EBEI-8. Building Code Revisions and Infrastructure Design Standards

Option Description

This option involves strengthening existing building codes and construction techniques for new infrastructure and structures in vulnerable coastal areas. Since building codes were originally intended to ensure the safety of new residential and commercial construction, pursuing this option will involve evaluating existing codes and design standards (including the Maryland Building Performance Standards (MBPS) and all local building code ordinances currently in place in Maryland jurisdictions) with respect to their proven effectiveness in past storm events, identifying causes of failure, and recommending and implementing changes to improve performance in the future. In addition to past performance, codes and standards should be reviewed and strengthened by taking into account future increased hazards caused by sea level rise and the associated possible increase in storm frequency and intensity caused by climate change. All types of building development (residential, commercial, and institutional) and public infrastructure (roads, bridges, water, and sewer) should be analyzed. Standards for marine-related structures (piers and wharves) should be included in this review as well.

In addition to the overall evaluation and strengthening of codes, the entire development process must change to allow for an integrative process that recognizes and takes into account potential impacts of SLR and climate change at all stages, including early design and decision making. Design professionals must look for ways to reduce future impacts, and local governments must increase plan review, inspection, and enforcement efforts.

This effort is ongoing at several levels. FEMA regularly publishes a "Summary Report on Building Performance" after major natural disasters (such as Hurricane Andrew and Hurricane Katrina). These reports study the damage resulting from the event, identify areas of strength and weakness in building design and construction, and recommend improvements. The International Code Council (ICC) also studies code effectiveness and regularly makes improvements to its codes. The MBPS and Maryland local building code ordinances make improvements by adoption of various ICC codes such as the 2006 International Existing Building Code (IEBC) and the 2006 International Energy Conservation Code (IECC). It is imperative that these future code reviews begin to consider the effects of climate change and SLR on the long-term sustainability of structures and infrastructure.

Option Design

Targets: All construction-related codes and design standards should be evaluated for their effectiveness in protecting against the future effects of climate change and SLR. The State of Maryland has adopted with modifications for Maryland law, the International Building Code (IBC) 2006 and the International Residential Code (IRC) 2006 as the Maryland Building Performance Standards (MBPS or Standards). As of July 2007, the Standards apply to all building structures within Maryland for which building permit applications are received by a local jurisdiction. Each local jurisdiction may, by local amendment, modify the provisions of the Standards to address issues relevant to that jurisdiction. Many jurisdictions have, in fact, made amendments in addition to the MBPS. Therefore, any review must include an evaluation of the

MBPS as well as local building code ordinances. (Building codes are largely enforced by local officials; attention to training and enforcement will be important to the successful implementation of future code improvements.) Reviews will include the following issues:

- *Elevation of buildings*— Maryland could enhance current FEMA requirements and mandate a statewide freeboard for all new construction in coastal flood hazard zones. Currently some local jurisdictions have adopted a freeboard requirement of 1.0 ft into their local floodplain ordinance. Freeboard is an elevation above a design high water level (base flood elevation). For example, the bottom of the lowest horizontal structural member should be elevated a minimum of 2 feet (or more) above the base flood elevation. This is especially pertinent with regard to SLR, since base flood elevations will be higher in the future. The required freeboard should relate to the amount of SLR expected, potential wave height, and the expected life of the structure. Experience from Hurricane Katrina shows that building elevation is the most effective deterrent to flood damage.
- *Foundation design*—Certain types of foundations are more effective in flood situations than others. Deep pile or column foundations are desired if significant erosion is possible in oceanfront locations as well as bay locations where the following conditions exist: erodibility of the soil, exposure to “damaging” waves (greater than 1.5 feet high), potential for velocity flow, potential for flood-borne debris, and required resistance to wind forces. These locations include FEMA identified V-zones (i.e., high hazard areas) as well as A-zones (i.e., areas within the 100-year flood zone and outside the V-zone).
- *Long-duration flood impacts*—Long-duration flooding, which may be a result of SLR in the future, can cause extensive damage to interior contents of buildings and building materials. Moisture entrapment within walls and floors can impact structural integrity and can cause biological and chemical contamination. Elevation will avoid this problem as will the use of flood-resistant building materials installed above the minimum elevation.
- *Debris impact*—Substantial damage can be caused by floating or wind-driven debris in a flood or storm event. Current codes and construction standards should be evaluated with regard to debris resistance.
- *Building envelope*—Building envelope is the entire exterior surface of a building, including walls, windows, doors, and roofs. All parts of the building envelope must provide protection from wind, wind pressure, and wind-borne debris. Building codes are very specific regarding these issues, but they should continually be reviewed and improved as needed.
- *Public infrastructure*—Design of future public projects, including roads, bridges, tunnels, landfills, water, and wastewater treatment plants, should consider the effects of climate change and SLR. In addition, standards should be developed for the modification of existing facilities in response to SLR.
- *Abandoned facilities*—Provisions should be made to minimize the negative impacts of structures and facilities that may be abandoned due to SLR. Such impacts may include navigational and environmental hazards.

Timing: This is primarily an ongoing effort. As noted above, codes are currently in place and should be implemented and enforced by everyone involved in the design and construction process. FEMA and the various code agencies continually evaluate the effectiveness of the code requirements, especially after a major event such as a hurricane or flood. These events provide essential information regarding the performance of code complaint structures and reveal areas in need of improvement. Training of enforcement personnel should also be an ongoing effort. Codes and design standards should be reviewed periodically in light of new science and evidence of climate change and SLR.

Parties Involved: All parties who are part of the design and construction process should be involved in this effort, including the ICC, design professionals such as architects and engineers, building materials manufacturers, building trade associations, the federal government (FEMA, National Weather Service, NOAA and USACE), state government (Maryland Emergency Management Agency [MEMA], Department of Housing and Community Development [DHCD], MDP, Maryland Drug Enforcement Agency [DEA], MD State Energy Office, DNR, and Maryland Department of Transportation [MDOT]), and local governments. Coordination with the Americans with Disabilities Act (ADA) is essential. Property owners also need to be aware of potential hazards and be presented with opportunities to become informed about the performance of their properties.

Implementation Mechanisms

Implementation of this option will initially involve an evaluation of all existing codes and regulations applicable in the State of Maryland (see above) with specific regard to the threats associated with climate change and SLR. To account for the expected lifespan of newly constructed buildings, this will involve looking many decades into the future and trying to predict how buildings will be impacted. If deficiencies are found, changes to codes, regulations, and laws will be necessary. Adequate enforcement of these codes, which is largely the responsibility of local governments, will be critical to the success of code improvements.

Related Policies/Programs in Place

As noted above, the State of Maryland has adopted with modifications for Maryland law, the IBC 2006 and the IRC 2006 as the Maryland Building Performance Standards (MBPS or Standards). As of July 2007, the Standards apply to all building structures within Maryland for which building permit applications are received by a local jurisdiction. Each local jurisdiction may, by local amendment, modify the provisions of the Standards to address issues relevant to that jurisdiction. Many jurisdictions have, in fact, made amendments in addition to the MBPS. Therefore, any review must include an evaluation of the MBPS as well as local building code ordinances. Building codes are largely enforced by local officials; attention to training and enforcement will be important to the successful implementation of future code improvements.

Codes are currently in place to regulate construction. The IBC is the primary building code. FEMA's flood insurance program is the primary source of flood protection regulations. State and local governments often complement these general programs with more site-specific regulations.

Estimation of Adaptation Benefits and Costs

Implementing a program for strengthening existing building codes and construction techniques for new infrastructure and structures in vulnerable areas will be subject to a variety of costs and will produce distinct benefits. As noted above, this option is focused on evaluating existing codes and standards for their effectiveness in protecting against the future effects of climate change and

SLR. The types of costs considered here are incremental to those that have already been incurred for developing and maintaining the existing framework of codes and standards in place in Maryland.

Incremental costs to address climate change through the implementation of strengthened codes fall into four major categories: assessment, new design requirements, training, and inspection. Assessment involves the costs for the comprehensive evaluation of existing statewide and local building codes and standards. New design requirements involve the future costs associated with meeting more stringent code requirements (e.g., freeboard requirements and higher safety factors for foundation design in coastal areas). Training involves the incremental costs associated with meeting the technical capacity needs of inspectors who will be charged with ensuring compliance with new codes. Finally, inspection involves new funding to ensure that an adequate number of trained code officials and inspectors are available.

The benefits associated with strengthened building and infrastructure codes in Maryland center on the degree to which they integrate climate change risks into the state's codes and standards framework. Future state building stock and infrastructure will be designed and installed subject to standards established in response to emerging knowledge about climate change. Insofar as uncertainties remain, an implicit precautionary approach will be applied. The gradual transition of building and infrastructure stock should better position Maryland to plan for and mitigate against future climate change risks. These benefits, while difficult to quantify, are nevertheless substantial and likely to be higher than the incremental costs associated with the implementation of the option.

Feasibility Issues

None identified for the evaluation of existing codes and regulations with specific regard to the threats associated with climate change and SLR.

Regarding long-range issues, the recommendation for adopting a statewide additional freeboard for new construction in coastal areas is dependent on current FEMA 100-year floodplain maps. If a 2.0-foot minimum freeboard requirement is put in place, additional protection measures also need to be implemented to provide the same level of protection in areas adjacent to the coastal 100-year floodplain. As the floodplain increases or rises 2 to 3 feet, the area adjacent to or behind the current coastal floodplain will also become inundated by the higher coastal floodplain. In order to provide the same level of protection to new construction within these "adjacent flood zones," the freeboard requirement also needs to address construction that falls within the anticipated sea level rise areas.

Status of Group Approval

Unanimous

Barriers to Consensus

None

EBEI-10. Disclosure

Option Description

With the ongoing and anticipated changes to the Maryland coastline associated with climate change, future property owners must be aware of the potential impacts that SLR, storm surge, and other effects of climate change may have on the property they are considering purchasing in order to make informed decisions. It is in the interest of prospective property owners to be fully informed of risks they are undertaking and potential insurance implications—as well as potential options for addressing these risks—at the time they are making the decision to purchase property. Such awareness will enable potential purchasers to better evaluate the appropriate uses of the property and will decrease the possibility of subsequent lawsuits and other disputes.

Option Design

This option is applicable to all counties bordering the Atlantic Ocean and the Chesapeake Bay.

Targets: Information on the following three items, among others, should be required at as many stages of property transaction and ownership as possible:

1. Notification of potential buyers in the property listings.
2. Disclosure notice at settlement.
3. Recording on the plat maps, zoning maps, and with the title and deed, with notice to the property owner, of relevant information collected by local, state, or federal agencies showing changes in the coastal boundaries and natural and topographical features (e.g., wetlands and dunes).

Timing: The timing for making disclosure information available for real estate transactions is immediate.

Parties Involved: Those parties directly involved in the transaction (i.e., the buyer and seller and their agents) and authorities with relevant information about physical changes to the coastal zone are involved.

Other: At various stages of property transactions and ownership, the information required to be disclosed should cover as many of the following types as possible:

1. General information about SLR, coastal storms, and coastal erosion and their impacts on the area (i.e., coastal counties). This could be in the form of a generic brochure, which could be developed by the state in concert with realtors and other stakeholders.
2. Whether the property is in an area that has been determined to be at risk from SLR and associated hazards by relevant authorities, such as the National Flood Insurance Program, Maryland Critical Areas Commission, NOAA, and Maryland DNR.

3. Any knowledge that the property owner has of any flooding, avulsion, erosion, or other significant damage to the natural or topographical features or any built structure that has occurred on the property.

Implementation Mechanisms

Implementation of this option will require changes to existing law in Maryland in two major areas. First, the state may require property owners or managers to provide general information on climate-related risks, similar to the general notice (pamphlet) regarding lead. This notice requirement could be triggered particularly for vulnerable properties: for lead, that includes residential buildings built before 1978; for SLR, that could include houses in coastal counties or those located in areas specifically identified as vulnerable to SLR, erosion, storm surges, and other related risks. Second, to the extent that a property owner or manager has knowledge regarding the risk to that particular property (presence of lead-based paint, or past flooding or erosion), the law would also require the property owner or manager to disclose that information.

Details on all aspects of this policy option will need to be worked out carefully at a future date.

Related Policies/Programs in Place

See Feasibility Issues section below.

Estimation of Adaptation Benefits and Costs

Implementing disclosure requirements for coastal hazards related to the transfer of residential and commercial properties is a fairly low-cost option. Because residential and commercial real estate in certain locations may be at greater risk due to climate change effects (e.g., rising sea levels, increased hurricane severity), the disclosure requirements are intended to serve as a public awareness function regarding the potential risks incurred by the buyer. Given the regional nature of coastal threats, this function is not limited to Maryland's coastal areas but serves to inform buyers that all coastal properties are subject to similar conditions.

The incremental costs are associated with developing the statutory framework to ensure that general and specific disclosure documents are included in the set of documents for purchasers of real property in the coastal counties of Maryland and that such information is also made available in real estate listings and recorded with local real estate records. These costs are likely to be de minimus. While one cost of this option may be a change in the profitability of real estate transactions in the coastal zone, the corollary benefits in awareness and preparedness of property owners and decreased needs for disaster relief will outweigh any costs of this option.

The incremental benefits associated with these disclosure requirements are difficult to quantify. It seems likely that the disclosure requirements will have a much smaller effect than the evolving perspectives of property insurers who may increase insurance premiums for properties located in coastal zones deemed vulnerable to climate change, or the perspective of lending institutions that may consider the property's value as having reduced collateral for a commercial or residential mortgage loan. It is not clear that disclosure itself would result in changes in the profitability of real estate transactions in the coastal zone, but the corollary benefits in awareness and preparedness of property owners and decreased needs for disaster relief will outweigh any costs of this option.

Feasibility Issues

These advice and notice requirements would build upon the implementation precedent of requiring residential property sellers to provide information regarding lead and lead-based paint (notification requirements regarding radon provide another precedent). Federal[1] and state[2] law require both general and specific disclosure regarding lead in residential housing transactions. In particular, persons selling or leasing most residential housing built before 1978 are required to provide purchasers and renters with a federally approved lead hazard information pamphlet (Protecting Your Family from Lead;[3] Maryland Real Property Disclosure and Disclaimer Statement[4]) and to disclose known lead-based paint and/or lead-based paint hazards in the sales contract.[5]

Status of Group Approval

Unanimous

Barriers to Consensus

None.

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1 24 CFR Part 35; 40 CFR Part 745; 9061 Fed. Reg. 61 (Mar. 6, 1996), available at: http://www.epa.gov/fedrgstr/EPA-TOX/1996/March/Day-06/pr-24120.pdf; see also, http://www.epa.gov/lead/pubs/selr_eng.pdf

2 COMAR, Real Property Article § 10-702, available at: http://mlis.state.md.us/asp/web_statutes.asp?grp&10-702

3 http://www.epa.gov/lead/pubs/leadpdfe.pdf

4 http://www.dllr.state.md.us/forms/danddform.doc

5 EPA, *Interpretative Guidance for the Real Estate Community on the Requirements for Disclosure of Information Concerning Lead-Based Paint in Housing,* August 20, 1996, available at: http://www.epa.gov/lead/pubs/1018fin.pdf

Acronyms and Abbreviations

ADA	Americans with Disabilities Act
CBOS	Chesapeake Bay Observing System
CCSP	Climate Change Science Program
CO-OPS	Center for Operational Oceanographic Products and Services
CORS	Continuously Operating Reference Stations
CSI	Comprehensive Shoreline Inventory
CZMA	Coastal Zone Management Act
DEA	[Maryland] Drug Enforcement Agency
DNR	[Maryland] Department of Natural Resources
EOTB	Eyes on the Bay
EPA	U.S. Environmental Protection Agency
FEMA	Federal Emergency Management Agency
GIS	geographic information system
GPS	global positioning system
HAZUS-MH	Hazards U.S. Multi-Hazard
HMP	Height Modernization Program
IBC	International Building Code
ICC	International Code Council
IEBC	International Existing Building Code
IECC	International Energy Conservation Code
IOOS	Integrated Ocean Observing System
IRC	International Residential Code
MACOORA	Mid-Atlantic Coastal Ocean Observing Regional Association
MANTA	Monitoring and Non-Tidal Assessment
MBPS	Maryland Building Performance Standards
MBSS	Maryland Biological Stream Survey
MDE	Maryland Department of the Environment
MDOT	Maryland Department of Transportation
MDP	Maryland Department of Planning
MEMA	Maryland Emergency Management Agency
NGS	National Geodetic Survey
NOAA	The National Oceanic and Atmospheric Administration
NSRS	National Spatial Reference System
NWLON	National Water Level Observation Network
RSD	Remote Sensing Division
SET	Surface Elevation Table
SLR	sea level rise
SSEA	Strategic Shore Erosion Assessment
STWG	Scientific and Technical Work Group
TEA	Tidewater Ecosystem Assessment
USACE	U.S. Army Corps of Engineers
USDA	U.S. Department of Agriculture

VIMS	Virginia Institute of Marine Sciences
WRAS	Watershed Restoration Action Strategy
DHCD	Department of Housing and Community Development

Future Built Environment Infrastructure

FBEI-1. Integrated Planning for Coastal Erosion, Coastal Storms, and Sea Level Rise

Option Description

Current coastal hazards, such as storm surge, coastal flooding, and erosion, are becoming more severe due to ongoing sea level rise (SLR). This policy option aims to increase the capacity of Maryland's state and local governments to adapt and respond effectively to threats associated with SLR and related hazards by increasing the integration of land-use, hazard management, and health care planning efforts by local, state, and regional entities. This option focuses on state and local comprehensive policy plans. It does not address operational plans or building codes.

This option includes two major components: (1) local coordination of comprehensive and other plans to reduce risks from SLR and associated coastal hazards, and (2) coordination of Maryland's state plans to reduce risks from SLR and associated coastal hazards.

Key to planning will be the establishment of a statewide standard estimate of expected SLR and the time frame for the future projected rise. Projections of the amount and rate of SLR will vary due to local conditions and are expected to change with increasing scientific understanding. Therefore, planning must reflect that uncertainty. Planning for SLR and related hazards must be flexible in that it must account for a diversity of places, time horizons, and a variety of hazards. These plans should appropriately implement strategies along the continuum from protection to retreat. They should also address mitigation activities, such as avoidance. Plans should include policies and suitable adaptation responses for the diversity of defined geographic areas.

The goals of this policy option are to increase coordination and consistency in planning approaches and to create a framework for the integration of other climate adaptation proposals, such as new building and zoning codes, adaptation of infrastructure, and protection of natural resources. Land-use–related plans need to be integrated with transportation and infrastructure plans, emergency plans, and natural resource plans.

There are three continuums that must be addressed in these plans: land use, risk, and response. Maryland's coastal lands run the gamut and include Assateague Island beaches, Ocean City condominiums, Middle River residential neighborhoods, and the 350-year-old historic downtown area of Annapolis. This diversity of land uses represents a tremendous challenge; thus, flexibility will be important in responding to SLR-related concerns.

Maryland's coastal community floodplains are mapped through the Federal Emergency Management Agency (FEMA) and the National Flood Insurance Program (NFIP). The Maryland Department of the Environment (MDE), Maryland Department of Natural Resources (DNR), and federal partners are completing additional hazard mapping of hurricane inundation and potential SLR flooding and inundation. These maps, taken together, will show a continuum of risk with some regions exposed to high velocity waves, while other areas may have only periodic shallow flooding. Government and private responses to these increased risks include protection in place, mitigation design, avoidance and retreat.

At a minimum, state and local plans would address potential threats in affected areas and strategies for a phased implementation response under the following categories:

- Land use, zoning, and development density regulations to reduce population and investment at risk;
- Public and market-based incentives of disincentives to reduce property damage and threats to human health;
- Anticipation and planning for adverse health consequences of flooding, storms, and storm surges (this planning should consider the physical and mental heath consequences);
- Provision of community infrastructure (i.e., roads, schools, public safety and medical facilities, water and wastewater systems, gas, electrical and communications utilities);
- Maintenance of existing and future natural resource lands and wildlife habitat, as well as working lands (i.e. agricultural and forest lands);
- Adaptive shoreline erosion control (non-structural and "living shorelines" approaches) and buffer management strategies, including the accommodation of future wetland migration corridors, where limited or no development is allowed; and,
- Public communication and outreach.

Greater integration and coordination of plans supporting public and private actions are recommended, as these processes provide an overarching mechanism necessary to facilitate more consistent and integrated statewide risk management. Specifically, the Maryland Department of Planning (MDP), DNR, and MDE, in consultation with local governments, should investigate the appropriate planning mechanisms to implement this policy option. Considerations should include current timing of plan updates, capacity of local governments, and availability of suitable data. The primary mechanism may be local comprehensive-plan elements, as required in Article 66b of the Annotated Code of Maryland.

This recommendation requires consideration of the plans that shape the comprehensive plan. The plans include, but are not limited to, appropriate infrastructure and community facilities (e.g., water and wastewater) land-use, municipal growth elements, sensitive areas and areas of special concern (e.g., floodplain management, Chesapeake Bay Critical Area, forest preservation), and special plans (e.g., marina and boating, Land Preservation Parks and Recreation Plans [LPPRP], shoreline and emergency management, and all hazard). Particular attention should be given to the integration of All Hazards Planning and the Comprehensive Planning processes, because there is currently no mechanism in place to coordinate these activities.

In addition, insight from Health Impact Assessments (HIAs) recommended in policy option HHSW-1 [Human Health, Safety and Welfare] should be incorporated into planning efforts. This recommendation is expected to form the policy basis at the state and local level for the implementation of EBEI-3 [Existing Built Environment and Infrastructure], Adaptation of Vulnerable Public and Private Sector Infrastructure. RRI-1 [Resources and Resource-Based

Industries], New Criteria for Identifying Natural Resource Priority Protection and Restoration Areas, will also be an important cross-linked adaptation option.

Option Design

Targets:

- Identify all public and private land at risk from SLR and storm surge. Regularly updated floodplain mapping, combined with predictive mapping of storm surge associated with specific weather events, should be undertaken. Local land-use regulations should be adapted to better anticipate these risks. State and local health departments should assess the potential health impacts.
- Local, state, and federal transportation planners will include SLR and storm surge vulnerability into short- and long-range transportation planning to avoid infrastructure expansion into vulnerable areas. Where existing infrastructure is already vulnerable, options should be evaluated to minimize risks, move infrastructure from vulnerable areas, or otherwise reduce vulnerabilities. A process similar to that under the Smart Growth Priority Funding Areas Act should be considered as a possible screening mechanism.
- Storm-water management calculations must also take into account the best available science on anticipated changes in precipitation associated with climate change in the Mid-Atlantic region and seek to accommodate potentially greater volumes of storm water within the watershed without creating or exacerbating downstream and coastal water quality, as well as habitat problems. All new development and transportation projects must include advanced "environmental site design" techniques to the maximum extent practicable for storm-water, such as infiltration, use of natural features, and bio-retention, over traditional storm-water management techniques.
- Infrastructure and development should be adaptable and resilient in areas where development cannot be avoided. Provide disincentives for development within high-vulnerability areas by ensuring that public funds are not spent on infrastructure that supports new development within vulnerable areas. Where feasible, the plan should identify where gradual realignment of existing structures, population density, land uses, and management approaches will be required to protect the long-term health, safety and welfare of Maryland residents.

Parties Involved: DNR, MDP, MDE, Maryland Department of Health and Mental Hygiene (DHMH), Maryland Department of Transportation (MDOT), Maryland Emergency Management Agency (MEMA), and local and county governments.

Timing: 2008, assess capacity of local governments; 2009, select appropriate planning implementation mechanisms at state and local levels; 2009, prepare proposed administration legislation; 2009, seek passage of legislation; 2010, prepare administrative guidelines and technical assistance materials; 2011, state and local plans begin to incorporate SLR response elements.

Other: Maryland Association of Counties (MACo), Maryland Municipal League (MML), affected local governments in Maryland's coastal zone, National Oceanic and Atmospheric Administration (NOAA), U.S. Geological Survey (USGS), and the U.S. Army Corps of Engineers (USACE).

Implementation Mechanisms

Assessment of Local Government Capacity

The current capacity of local governments to undertake necessary steps to implement these actions is unknown, but it is expected to be insufficient to successfully complete these actions in a timely manner. Therefore, it is recommended that the DNR, MDE, MDP, MDOT, and MEMA work with MML and MACo to estimate that capacity by performing or providing

- A survey of local governments throughout the state to assess the planning measures already in place for SLR, assess the perceived barriers, and determine how best to share information between local, county, and state governments;
- A technical review and assessment of planning guidelines used by local communities and municipalities within the coastal zone; and
- Guidance to assist local governments with identifying specific measures (e.g., local land-use regulations and ordinances) to adapt to SLR and increasing coastal hazards.

Based on findings of the capacity assessment, state offerings of technical assistance, academic assistance, grants to local governments, and support for local geographic information system (GIS) mapping may be appropriate.

Selection of Plan Mechanisms and Development of Guidelines

Planning guidelines would be developed jointly by MDP, DNR, and MDE in consultation with local governments to ensure consistency and clarity and to facilitate integration of the new plan element with existing comprehensive planning and zoning requirements. Of particular importance is the need for the SLR element to clearly identify, under various scenarios, how the provision of public infrastructure may change (i.e., whether local governments plan to fortify or rebuild damaged infrastructure, reduce the footprint of vulnerable or damaged infrastructure, or abandon or relocate critical public infrastructure). Local governments should also evaluate the estimated costs and benefits of proposed solutions and associated funding mechanisms. These analyses and decisions are of monumental importance to existing and future property owners, insurers, emergency personnel, local, state, and federal government agencies, elected officials, the business community, and others.

Maryland Planning Article 66B

Implementation of these recommendations could include amendments to §3.06(b) of Article 66B of the Annotated Code of Maryland to expand sensitive areas, or a section on SLR could be added under county comprehensive and local hazard mitigation plans. These efforts should draw on statewide mapping and monitoring efforts. Additional modifications to the Chesapeake Bay Critical Area Act (DNR Article, §8-1807) and implementing criteria (Code of Maryland Regulations [COMAR], Title 27) to enhance SLR adaptation and response might be required.

State Finance and Procurement Article §5-611

The State Finance and Procurement Article, Title 5, Subtitle 6, establishes the authority for the MDP to define “areas of critical state concern.” MDP, DNR, MDE, and local governments should work together to define the geographic limits of areas potentially impacted by SLR, coastal erosion, and storm inundation. Once defined, MDP and local governments should act to more formally designate these areas as "areas of critical state concern." This will allow the state to apply "federal consistency," which refers to the review process mandated by Section 307 of the Federal Coastal Zone Management Act of 1972, as amended (CZMA), and NOAA regulations (15 CFR part 930). The CZMA requires federal actions likely to affect any land or water use or natural resource of a state's coastal zone to be conducted in a manner consistent with a state's federally approved Coastal Zone Management Program (CZMP). The CZMA federal consistency requirement applies to direct federal activities, such as development projects, licenses or permits, and assistance to state and local governments. Federal consistency determination must be based on enforceable policies officially incorporated into the state's CZMP.

Capital Planning Component

Capital project planning efforts should include estimations of vulnerability to SLR and storm surge for new or modified infrastructure. This process will consider broad floodplain management criteria to ensure that development occurs in areas that best reduce and minimize storm and flood hazards; facilitate natural infiltration; protect and restore riparian buffers, wetlands, and forests; and allow wetland migration corridors.

Emergency Management and Mitigation Plans

The adverse health consequences of flooding, storms, and storm surges are complex and far-reaching, and they include the physical health effects experienced during the event or clean-up process or from effects brought about by damage to infrastructure, including population displacement. The physical effects largely manifest themselves within weeks or months following the event and may be direct (e.g., injuries) or indirect (e.g., increased rates of vector-borne and other diseases). Extreme weather events are also associated with mental health effects, such as post-traumatic stress disorder, resulting from experiencing the event or from the recovery process. These psychological effects tend to be much longer lasting and may be worse than the direct physical effects.

To address these risks, effective approaches will be developed in collaboration with appropriate public health agencies and stakeholders to communicate appropriate responses that protect human health during large-scale floods, storms, and storm surges. Of particular concern are communication systems and plans that address health issues associated with low-income and underserved populations and other vulnerable groups. Plans will be developed for moving critical acute and long-term care facilities if they need to be closed because SLR, storm surges, or flooding may put them at risk. The plans will ensure that climate change concerns are integrated into activities of the Maryland Institute for Emergency Medical Services Systems (MIEMSS) and other organizations engaged in disaster response. Stakeholders will include managers of hospitals, public buildings, and infrastructure that provide emergency security, communications, and health services to reduce the vulnerability of critical activities and equipment during an extreme event or climate-related event.

Efforts to link locally developed and adopted comprehensive plans and emergency management plans, as well as the planning processes used to develop these plans, must be accomplished as described above.

Integration Across State and Local Plans

Planning policies adopted at the state level will be integrated with local efforts at three levels of planning. At the broadest level of planning, state and federally mandated efforts (i.e., the Maryland Comprehensive Master Plan, the Maryland Critical Area Master Plan, Maryland and the U.S. All Hazard Plans, the Maryland Transportation Plan, and the Maryland and U.S. Master Water and Sewerage Plans) would guide adoption of comprehensive classifications of impacts and policy response.

Local planning requirements would address in detail the design requirements for public and private development in areas at risk from SLR and associated hazards. Examples include Marina, Boating and Water Facility; Emergency Response; Erosion Control; Floodplain Management; and Shoreline Master Plans. Planning for all publicly funded projects though Capital Plans would require screening for possible SLR impacts and establish design standards for mitigating impacts.

Related Policies/Programs in Place

The Maryland Coastal Program Coastal Communities Initiative provides technical and financial assistance to local governments to promote the incorporation of natural resource and coastal management (e.g., coastal hazards, public access, water-use activities) issues into local planning and permitting activities. Additionally, a number of state-sponsored activities related to this option are currently underway: hazard mitigation planning, incentives and technical assistance for soft shoreline erosion control, SLR and storm surge mapping, green and blue infrastructure assessments, and an evaluation of growth management tools in coastal areas.

The Maryland Coastal Program is currently providing funding to Dorchester, Somerset, and Worcester counties to develop SLR planning guidance for each respective county. The purpose of the written guidance documents is to further the use of SLR and coastal hazard data and mapping products (made available through application of the light detection and ranging [LIDAR] data) in planning for and responding to SLR and coastal hazards at the local level. The three projects will map out the process, methodology (i.e., draft language), and a proposed timeline for incorporating SLR and coastal hazard response preparation into local planning processes and frameworks. The guidance will address the following four phases of SLR and coastal hazards planning: (1) Vulnerability and Impact Assessment; (2) Long-Range and Comprehensive Planning; (3) Code, Regulation, and Development Standards; and (4) Public Education and Outreach. The guidance will also provide recommendations for sequencing and integrating the four planning phases and will identify financial and technical assistance needs at the local level. Final products are expected in September 2008.

Mapping efforts are already underway, such as Maryland Shorelines Online (MSO) and Maryland Statewide Basemap (*i*Map)—an Internet-based interactive map suitable for use by state agencies, local governments, and the public. In addition, the policy option proposal for Integrated Geographic Information Systems (IGIS): Mapping Modeling and Monitoring, will provide local and regional governments with access to required spatial information for these planning efforts.

The DHMH Office of Preparedness and Response (OP&R) coordinates with local health departments and MEMA on the health response portion of this option.

Estimation of Adaptation Benefits and Costs

This policy option aims to increase the capacity of the Maryland government to respond effectively to threats associated with SLR and associated hazards by increasing the integration of local, state, and regional land-use, hazard management, and health care planning efforts. It emphasizes the need for careful preparation before disasters to minimize loss and to guide post-disaster response toward greater community resilience. The benefits of the effort are its many contributions to risk reduction. Such benefits, which relate to identifcation and implementation of risk management strategies, are difficult to quantify.

The improved coordination across planning efforts will increase flexibility in the design and selection of future response options by reducing implementation obstacles (e.g., response time and inconsistent implementation) and by increasing the pool of strategies likely to be more effective and timely. Training efforts suggested in this policy option and others will disseminate information to people on the risks of SLR and associated hazards through implementation and by establishing a broad foundation of knowledgeable parties who are better able to identify future adaptation options. This policy option addresses the need to improve coordination of diverse planning efforts in Maryland and will provide benefits for other planning goals.

This option involves two main sets of costs: (1) legislative development, research, and training elements require investments of staff time and communications resources; and (2) increasing capacity to conduct planning, according to new criteria and implementation of planning processes. These costs are more broadly distributed among local, state, and regional planning staff. The training costs will be similar to those associated with other changes to state planning. The implementation costs are most likely to be incremental additions to the cost of ongoing planning processes.

In 2008, staff time will be required to research and draft proposed administration legislation. Two specific projects have been identified:

- A survey of local governments throughout the state to assess the planning measures already in place for SLR, the perceived barriers, and how best to share information between local, county, and state governments; and
- A technical review and assessment of planning guidelines used by local communities and municipalities within the coastal zone.

During 2009, staff will support passage of the legislation. Assuming successful passage, preparation of technical assistance materials that identify specific measures (e.g., local land use regulations and ordinances) will take place in 2010. Beginning in 2011, localities revising their comprehensive plans will be required to incorporate the new integrative elements.

Feasibility Issues

Full benefit of this effort will depend on access to local information on SLR and associated hazards for planning purposes. A policy option designed to address monitoring, data management and quality, GIS, and integration of required modeling efforts is recommended elsewhere in this report. In addition, public awareness of the risks will be important to the successful implementation of strategies to increase resilience. An option that addresses approaches to increasing public awareness is included in this report.

Status of Group Approval

Unanimous

Barriers to Consensus

None.

FBEI-2. Adaptation and Response Performance Measurement

Option Description

A two-part strategy is proposed to advance action on key recommendations and promote integration of existing programs with recommendations. Under this option, each agency with a mission affected by SLR, associated hazards, and recommended policy options will review the recommendations of the Maryland Commission on Climate Change (MCCC) and the adaptation policy options developed by the Adaptation and Response Working Group (ARWG), report on how these issues and recommendations relate to their missions, and outline an agency action plan for integrating SLR and associated hazards into their planning and evaluation procedures. These revised procedures will be the basis for establishing performance measures.

The report should address opportunities for integration with existing programs, actions initiated, new programmatic efforts, and barriers to response; it should also provide a timeline for response. Particular attention should be given to state and local program implementation to ensure that future decisions and actions adequately consider and respond to anticipated impacts due to SLR and increases in storm frequency and intensity. Greater detail on report content is discussed under implementation mechanisms below. These reports are to be submitted to the Governor, the Executive Committee, Cabinet members, and Committee Chairs with copies to the MCCC. Information from these reports would support ongoing evaluation of Maryland's efforts, capacities, needs, and progress in addressing climate change mitigation and adaptation.

Performance measures will be reported annually. These measures should document processes and progress in adapting to SLR and associated hazards. Revised procedures and performance measures would remain in place, unless new information on risks or policy changes emerges.

Option Design

Targets: The relevant subset of potential impacts and policy options will vary among agencies. However, the agencies should evaluate and identify needed changes to their programs, policies, standards, and activities in the areas of engineering, design, and construction; siting and planning; funding; coastal zone management activities such as permitting of shoreline activities and monitoring; staff training programs; and education and outreach programs. These efforts should model best practices; ensure that funding is consistent with the broad goal of reducing exposure to coastal risks; and utilize the most recent scientific information, spatial mapping resources, and monitoring systems on climate change impacts in Maryland.

Timing: Reports and first indicator data will be submitted within a year of publication of MCCC Mitigation, Adaptation, and Science Working Group reports. Draft language for necessary changes to rules, forms, evaluation criteria, and policies and procedures should be prepared concurrently with the report to facilitate implementation. If changes require legislation or adoption of new regulations, then proposals for the recommended changes should be brought forward in the second year. Agencies will be asked to participate in the development of a reporting framework to accommodate agency-designed measures and ensure clarity, consistency, and measurability of indicators among agencies. Performance indicators will be submitted annually.

Parties Involved: A large number of state agencies will be affected by the changing risks and adaptation policy options: Maryland Department of Aging (MDOA); Department of Budget and Management (DBM); Department of Business and Economic Development (DBED); Community Initiatives; Maryland State Department of Education (MSDE); MEMA; MDE; Maryland Environmental Services (MES); Department of General Services (DGS); Governor's Grants Office of Maryland (GGO); Maryland Health Care Commission (MHCC); DHMH; Maryland Higher Education Commission (MHEC); Governor's Office of Homeland Security (GOHS); Department of Housing and Community Development (DHCD); DNR; Maryland Insurance Administration (MIA); Department of Labor, Licensing and Regulation (DLLR); MIEMSS; MDP; Maryland Public Broadcasting Commission (MPBC); Public Service Commission (PSC); Maryland Board of Public Works (BPW); State Retirement and Pension System (SRPS); Rural Maryland Council (RMC); Maryland Secretary of State; Governor's Office on Service and Volunteerism (GOSV); Maryland Office of Tourism; MDOT; State Treasurer's Office (STO); University System of Maryland (USM); and Volunteer Maryland (VM).

Implementation Mechanisms

Orientation and training will familiarize principal agency staff involved in the review process with Maryland-specific information on SLR, associated hazards, and adaptation policies. The initial agency reports on adaptation should

- Identify programs affected by SLR, storm frequency, and storm intensity;
- Evaluate programmatic and procedural modifications needed to address these issues, including issues that may involve legislative or regulatory changes;
- Provide a timeline for modifications that will
  - Provide draft language for early implementation of changes that can be implemented without legislation or adoption of new regulations;
  - Identify changes that require legislation or adoption of regulations for introduction in the following year; and
  - Identify changes that require additional study or information over a longer period, prior to development of necessary changes to programs, policies, standards, and activities.
- Specify mechanisms to ensure that policies are updated regularly and in accordance with science and observed changes;
- Develop a reporting framework that will accommodate measures identified by agencies and will ensure clarity, consistency, and measurability of indicators among them; and
- Provide and annual report on performance indicators.

Related Policies/Programs in Place

All agencies identified have ongoing review processes and reporting requirements for programs that might be influenced by SLR and associated hazards directly or by proposed policy options.

BayStat: Governor Martin O'Malley created BayStat by Executive Order in February 2007. BayStat is a powerful new statewide tool designed to assess, coordinate, and target Maryland's Chesapeake Bay restoration programs and to inform its citizens on progress. Each month, Governor O'Malley meets with his BayStat team—the Secretaries of Maryland Department of Agriculture (MDA), MDE, DNR, and MDP, scientists from the University of Maryland (UM) and other key staff—to make sure Bay restoration work is on track. These sessions provide a regular opportunity for the team to assess progress, evaluate what is working and what is not, and adapt the efforts accordingly. BayStat allows Maryland state agencies to work smarter by coordinating efforts and programs, base decisions on the best available science, target resources to get the best value, and be more open and accountable to Maryland citizens.

National Coastal Zone Management Performance Measures System (NCMPMS): NOAA has established the NCMPMS to serve as a mechanism for quantifying the national impact of the CZMA. The system consists of performance indicators to track how well the CZMP and the National Estuarine Research Reserve System (NERRS) are achieving CZMA objectives. The NCMPMS includes performance indicators for Public Access, Government Coordination, Coastal Habitat, Coastal Water Quality, Coastal Hazards, Community Development, and Coastal Dependent Uses. The Maryland Coastal Program has submitted its performance measurement data in accordance with the program in 2006, 2007, and 2008.

Estimation of Adaptation Benefits and Costs

Mainstreaming consideration of SLR and associated impacts into policy and procedures promotes a comprehensive approach to adaptation that reaches across the diverse programs potentially affected by efforts to adapt to SLR and associated hazards. Absent a full review of programs that may be affected, the benefits cannot be quantified, but they will include reduction of economic, social, health, and ecological risks to SLR and associated hazards. The process of refining policy and procedures will result in increased staff awareness and understanding of the climate change, SLR, and associated potential impacts for Maryland. The deeper engagement offers greater capacity for sophisticated, innovative responses to new information.

This policy option has relatively low capital needs, because it is designed to mainstream adaptation issues into current programs and review processes. In the first year, it will require each affected agency to conduct an analysis of existing programs and procedures and report on proposed refinements to those processes. This initial effort in the first year report and direct follow-up actions in subsequent years will require dedicated staff time for coordinating staff in each program area. In addition, agency staff most closely involved with this review and refinement process are likely to require additional training on climate change, SLR, and associated impacts to ensure that they bring to the process a firm knowledge base, informed by the most recent science conducted for Maryland.

Feasibility Issues

Internal constraints to agencies' abilities to address these changes are likely to be affected by budget limitations and availability of staff time. In some cases, external factors, such as legislative issues and potential agency need for enabling legislation, might limit potential to make certain changes. Agency staff may require additional training on SLR and associated hazards in order to conduct thorough evaluations of their programs.

Status of Group Approval

Unanimous

Barriers to Consensus

None.

FBEI-5. Climate Change and Insurance Blue Ribbon Advisory Committee

Option Description

Insurance is a central, cross-cutting element to an overall adaptation strategy. The insurance industry faces certain SLR, coastal erosion, and increased likelihood of severe storms, including hurricanes. Climate change is likely to have widespread impacts on the insurance industry and is also likely to have significant impacts on the financial condition of insurers and reinsurers, the ability to pay future claims and, thus, on the availability and affordability of insurance to Maryland's citizens and businesses. The structure of insurance will shape social investments and the distribution of risks through society, as well as the willingness of financial institutions to make capital available for mortgages and other capital investments in at-risk areas. Other policy options recommended here, such as those focusing on building code revisions, integrated planning, and modeling potential impacts, take a proactive approach to reducing risk, avoiding future costs, and helping the state to maintain insurability of investments. This option focuses on assessing changing risks and opportunities throughout the insurance arena.

There are a number of approaches being discussed and tested in other states and many changes taking place in the industry. In some cases, the vulnerability of state insurance systems to climate change is becoming clearer. In Florida, where 79% of insured property sits along the coast, homeowner insurance premiums have risen more than in any other state, with the average policy increasing by 88% between 2001 and 2006. Florida has a liability of over $27 billion dollars for a hurricane with an estimated return time of 100 years.[1] Some insurance companies are no longer writing new coverage in the state.[2] In states that are insurers of last resort, the possibility of increasingly expensive or unavailable insurance coverage could pose significant problems for the state's financial and fiscal health. States not currently the last recourse for insurance may be pressured to assume that role if adverse results force insurers to withdraw.

Two measures in particular can help Maryland to assess its options for state regulation of insurance in the face of climate change. First, there is a need for information on the risks posed by climate change and how insurers and reinsurers are managing those risks. Second, it is important to have a focused assessment of this issue and a strategy for managing the ramifications of climate change risks and uncertainties.

Blue Ribbon Advisory Committee. It is recommended that the Governor establish a blue ribbon advisory committee to study and report on potential impacts of climate change on insurance in the state, determine the potential role for insurance in promoting environmental management goals, and address the relationship between changing building and design standards and insurance. Further, the advisory committee should be independently chaired, and the MIA should take an active role in the advisory committee without chairing it to ensure that the breadth of

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[1] Financial Services Commission, Florida Office of Insurance Regulation, "Annual Report of Aggregate Net Probable Maximum Losses, Financing Options, And Potential Assessments." February 2008.

[2] Environmental Defense, "Blown Away: How Global Warming is Eroding the Availability of Insurance Coverage in America's Coastal States," 2007.

stakeholder concerns is heard. This committee would consider policy options identified by the National Association of Insurance Commissioners (NAIC) on climate change, incentives (or disincentives) in the current insurance market, innovative means for insurers to support best practices in risk reduction, and forms of public–private partnerships to support industry advance in these areas. As part of this effort, the committee should consider whether it is possible to develop a program similar to the Community Rating System (CRS) within the NFIP, which would encourage local governments to implement protective or adaptive measures by offering reduced insurance rates for risk-reducing actions.

Enhanced Disclosure of Climate Risks. It is also recommended that the MIA consider requiring insurers operating in the State of Maryland to disclose to their investors the risks posed by climate change, and what steps the companies are taking to manage those risks. At a minimum, the MIA could consider requiring disclosure of the steps taken to assess the impact of climate change in the state, the results of the assessment over various time periods (short term to long term), and the degree to which climate risks could affect the company's access to reinsurance, solvency, risks in its own investment portfolio, and possible effects on availability and affordability of coverage.

Option Design

There are two actions in this option:

1. Create a Blue Ribbon Advisory Committee to advise the MIA and the Governor of the risks climate change poses to the availability and affordability of insurance for Maryland citizens and businesses, and

2. Require the MIA to study and report on the costs and benefits of requiring greater disclosure of the risks posed by climate change to investors on the part of all insurance companies operating in the State of Maryland.

Targets:
The Blue Ribbon Advisory Committee should consider the following key issues:

- Assess whether data available to insurers are adequate to assess risks posed by climate change (including SLR) and recommend steps to improve data deficiencies;
- Assess the degree to which adaptive options (e.g., zoning that recognizes risks of building in high-risk areas and improved building codes to protect against more severe weather and flooding) may mitigate insured losses due to climate change and whether insurance rate structures could be constructed that provide incentives for early adaptive actions;
- Assess the accuracy and quality of climate initiatives on the part of insurers; and
- Assess options to promote partnerships with policyholders for loss mitigation.

Timing: The advisory committee should be established and provide an initial report back within one year.

Parties Involved: MIA, DNR, DHMH, MDP, representatives of insurance and reinsurance companies (representing the spectrum of insurance [e.g., property and casualty, life and health, directors and officers insurance]), homeowners and property developers, representatives of public or private institutions providing essential infrastructure services (e.g., electricity, water and sewerage, and telecommunications), and businesses whose access to insurance is essential for continued operation.

Other: Inevitably, there will be tension between the insurance companies and those insured, particularly when disasters occur. In some cases, most recently in Florida, many insurance companies curtailed their property and casualty businesses along the coastline, in anticipation of more damaging storms, increased incidence of severe weather, and SLR. The loss of insurability, or increasingly expensive coverage, may well be an effective mechanism to discourage further development in areas most at risk from the effects of climate change, and may well be something Maryland policymakers should consider. However, changed coverage and loss of affordability can also be extraordinarily damaging to the reputations of insurers, even if the actions they take are in the long-term beneficial to public interest. It would be useful for the commission to not only consider the needs of Maryland's homeowners and businesses in the work of the commission, but also to take into account the needs of the insurance companies.

Implementation Mechanisms

An advisory committee composed of staff from the MIA, MEMA, MDP, homeowners and municipalities vulnerable to damage from SLR, and representatives from associated industries such as insurance and reinsurance companies would meet to consider major issues. They would be expected to bring in additional outside experts to inform their discussions. It is recommended that the chair of the advisory committee be an independent outside expert.

Related Policies/Programs in Place

The MIA has joined the NAIC Climate Change and Global Warming (EX) Task Force.

Maryland Task Force on the Availability and Affordability of Property Insurance in Coastal Areas. In recognition of concerns over changes in the availability and affordability of property insurance in coastal areas all along the East Coast and into the Gulf, and in response to questions concerning the availability and affordability of property insurance in Maryland's coastal areas, the Maryland General Assembly, through signature of the Governor, enacted House Bill 1442 (Chapter 486 (2007)) "Task Force on the Availability and Affordability of Property Insurance in Coastal Areas." The statutory purpose of the Task Force was to "examine methods to ensure the continued availability and affordability of property insurance in coastal areas of Maryland." The Task Force issued its final report in March 2008; the following are its recommendations:

- Require any insurer seeking to refuse to underwrite or renew a risk based solely on the fact the risk is located in a certain geographic area to obtain the prior approval of the Insurance Commissioner. This recommendation would require legislation to amend the existing statute, Section 19-107 of the Insurance Article.
- Require any insurer seeking to use catastrophe modeling as a basis for its rating and underwriting to have its catastrophe model reviewed and approved for use by the Insurance Commissioner. This recommendation would require legislation to be supplemented by regulation.

- Require any insurer seeking to apply a mandatory and separate deductible for losses arising out of a hurricane or named storm in an amount greater than 5% to obtain the prior approval of the Insurance Commissioner. This recommendation would require new legislation, because the Insurance Article currently has no such restriction.
- Require any insurer seeking to apply a separate deductible for losses arising out of a hurricane or named storm to advise the insured of this separate deductible and its amount in the Annual Summary of Coverages and Exclusions, as required by Section 19-205 of the Insurance Article. This recommendation will require an amendment to the existing statute.
- Require any insurer seeking to apply a separate deductible for losses arising out of a hurricane or named storm to have common language that operates as a trigger for the application of the deductible. It is recommended that a deductible be triggered when the National Weather Service (NWS) has issued a Hurricane or Named Storm Warning for the State of Maryland; it will be removed 24 hours after the NSW has cancelled the Hurricane or Named Storm Warning or Watch. This recommendation will require new legislation, because the Insurance Article does not address this matter.
- Require the development of a statewide building code to apply to all new construction and major renovations (equating to more than 50% of the property), with the requirement that residential dwellings meet the International Residential Code (IRC) and that commercial construction meet the International Building Code (IBC). This recommendation will require new legislation.
- Encourage mitigation efforts taken by the insured to protect their properties in the event of a loss by requiring insurers to provide a discount on the policy premium to those insured. The Insurance Commissioner will identify the mitigation efforts and establish the appropriate amount of the discount. This recommendation will require legislation supplemented by regulation.
- Provide the Commissioner with the authority to take the necessary actions, with respect to submission of claims, grace period for payment of premiums, postponements of cancellations and nonrenewals, and other powers as needed to protect the citizens of the state when the Governor has declared a state of emergency. This recommendation will require new legislation, because the Insurance Article does not currently provide the Commissioner with this type of authority.
- Request that the MIA study the desirability and feasibility of a State Catastrophe Fund.

The Task Force concluded that neither availability or affordability of property insurance in the coastal areas of Maryland are issues but that it must work to make sure the situation remains that way and the marketplace continues to be stable. Thus, the Task Force encouraged the Maryland General Assembly to implement legislation to codify its recommendations.

House Bill 1353, Omnibus Coastal Property Insurance Reform Act. This Act, which passed in the 2008 Legislative session, states that insurers of homes cannot adopt an underwriting standard requiring a set deductible unless they've received approval from the Insurance Commissioner to do so. The Bill goes on to say that the deductible is subject to timing and percentage of policy limitations. Discounts are required where homeowners have made improvements that reduce risks inherent in coastal zones provided the homeowners have used licensed contractors and the improvements are inspected for compliance. Catastrophic risk assessments should be used to set rates. The actual text of the law is footnoted below.[3]

The Act also requires the DHCD to conduct reviews and provide reports by specific dates to allow for the implementation of this Act and for other initiatives related to coastal property insurance.

Estimation of Adaptation Benefits and Costs

This option calls for investigating insurance issues specific to Maryland and identifying policies and practices that best meet the state's needs. The option does not commit the state to a course of action but seeks to inform a long-term policy process for establishing legal and financial obligations that may be difficult to adjust in the future. By drawing a diverse set of stakeholders into a dialogue on insurance issues, this process will create a knowledge resource specifically attuned to Maryland's concerns. The potential benefits depend on emerging knowledge of vulnerability and risks as well as investment responses to climate change risks; thus, they are difficult to fully anticipate. However, the effort will benefit the state by informing decisions about the government liability associated with various insurance strategies; identifying insurance options to meet the needs of the residents and businesses in the state; creating a forum for insurers, government, and consumers to discuss the role of insurance in managing climate risks; and providing access to information on the risks faced by insurance agencies and possible impacts on the accessibility and affordability of coverage.

Option costs are associated with staffing and convening an advisory committee and overseeing the disclosure process. There will be costs for staff time for organizing the committee, research to support committee efforts, reports by the staff and communication and outreach on findings. The committee is expected to meet over the course of one year. The disclosure process would pose an incremental cost to the MIA. The full benefit of this effort will depend on a strong understanding of risks for Maryland. The proposed inventory of public and private investment along the coast, integrated geographic information system (IGIS) , SLR monitoring, and science studies are associated costs.

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[3] " [This law] prohibits an insurer *that issues a policy of homeowner's insurance* from adopting an underwriting standard that requires a certain deductible unless the insurer has made a certain filing and obtained approval from the Commissioner; providing that if an insurer has adopted a certain underwriting standard that requires a deductible equal to a percentage of the policy limits of a policy, the deductible may only be applicable during a certain time; requiring an insurer that has adopted a certain underwriting standard to send a certain annual statement; requiring certain insurers to offer a certain premium discount to certain policyholders who submit certain proof of certain improvements made to a certain insured premises; requiring certain improvements to be completed by certain licensed contractors; authorizing an insurer to inspect certain improvements; requiring certain premium discounts to be in compliance with certain provisions of law; requiring certain insurers to provide a certain annual statement; requiring certain insurers that use catastrophic risk planning or other models in setting *homeowner's insurance* rates to file certain information with the Commissioner and explain certain information and make certain arrangements; providing that certain information is proprietary and confidential commercial information under a certain provision of law; authorizing the Commissioner to adopt certain regulations; requiring a certain insurer to file a certain plan at a certain time; providing for the contents of the plan; prohibiting the plan from taking effect until a certain time after a certain filing; authorizing the Commissioner to extend a certain waiting period for a certain time upon a certain notice; providing that a certain filing is deemed approved unless disapproved by a certain time; authorizing the Commissioner to allow a certain insurer to implement a certain plan within a certain time; requiring the Commissioner to approve the plan under certain circumstances; requiring the Commissioner to assess a certain impact; requiring the Commissioner to state certain points of objection and certain amendments under certain circumstances; requiring a certain insurer to file a certain amended plan within a certain time; prohibiting any intended withdrawal in accordance with a certain plan until a certain plan is approved; and, defining certain terms."

Feasibility Issues

This effort will require a limited amount of funding and committed staff time, but no exceptional feasibility issues have been identified.

Status of Group Approval

Unanimous

Barriers to Consensus

None.

FBEI-6. Integrated Geographic Information Systems: Mapping, Modeling, and Monitoring

Option Description

Maryland's coast is particularly vulnerable to episodic (i.e., hurricanes and Nor'easters) and chronic hazards associated with shore erosion, coastal flooding, storm surge, and inundation. These hazards are driven by and exacerbated by climate change and SLR, which occurs in the mid-Atlantic region at a rate nearly double the global average. SLR poses a significant threat to resources and infrastructure in Maryland's coastal zone. These impacts are likely to escalate as growth and development continues, especially within low-lying Eastern Shore communities.

In recognition of the state's vulnerability to SLR and its ensuing coastal hazards, Maryland's state agencies have been aggressively acquiring and analyzing various data and technological resources (see Related Policies and Programs) to gain a better understanding of SLR vulnerability and to increase the state and local government capacity to adapt and respond. To date, the State of Maryland has amassed a significant amount of data and undertaken state-of-the-art research, making Maryland a national leader in SLR modeling, research, and response planning. However, more work in the following areas is needed to complete statewide SLR modeling and develop mapping and monitoring products to support state and local SLR adaptation and response planning efforts:

- Complete statewide SLR inundation and storm surge modeling on a scale appropriate for state and local planning;
- Adopt a production and maintenance schedule for mapping and modeling activities; include the anticipated costs, financing options, and data sources; and increase the accuracy of predicted results;
- Ensure that state and local governments have easy access to the comprehensive body of information necessary for planning and response activities;
- Review institutional and organizational data management practices and make recommendations to enhance efficiency and cost-effectiveness of data gathering, sharing, maintenance and processing efforts and to minimize duplication of effort, data, and modeling redundancies;
- Create a digital spatial inventory of infrastructure potentially impacted by SLR that identifies public and private systems and facilities and threatened historical structures. This database should be maintained relative to SLR projections and scenarios;
- Utilize GIS systems to model and monitor specific "leading indicators" of climate change impacts—indicators that are representative of specific geographic ranges, behaviors, or population characteristics of certain species (e.g., plants, birds, mammals, and insects) known to be hypersensitive to SLR and other climatic changes. See Policy Option EBEI-2, Observation Systems for Changes in Coastal Areas, for more information; and
- Enhance the integration of SLR and other climate change data, research, and technology into state and local SLR adaptation and response planning efforts.

In addition, participating agencies should coordinate requests from Maryland to federal agencies asking them to provide regular updates of flood risk maps and to account for climate change risk in these mapping efforts.

Option Design

Targets: The effort will provide comprehensive coverage for the state and ensure regular updates of data, models, and maps. It will also strongly encourage and support requests to federal agencies for regular updating of flood risk maps and accounting for potential climate change impacts on risk in these maps. These maps will be made broadly accessible to professionals and the public to support adaptation planning and understanding of risks and processes of change.

Timing: This effort will support the ongoing efforts of MDP, Maryland DNR, MDE, and DHMH to integrate GIS data and improve data quality standards.

Parties Involved: Maryland DNR, MDE, MDOT, MEMA, MDP, and DHMH, *i*Map, Maryland State Geographic Information Committee (MSGIC), and USM.

Other: Identify other factors or parties that would need to be engaged for successful implementation of the option in the state.

Implementation Mechanisms

This effort will build on ongoing efforts of the Maryland DNR, MDE, MDP, MEMA, and DHMH to improve the integration and data quality standards of their ongoing data acquisition, mapping, and modeling efforts.

Implementation of this policy option should be intrinsically linked with *i*Map and will provide access to standardized information (e.g., imagery, roads, streams, place names, and property information) to serve as a base on which to overlay other data, such as the locations of features or resources at risk from SLR or predicted water levels from storm surge modeling. Anticipated deployment of Phase I of *i*Map is Spring 2008. The coordination of maps and model output will be supported by broadly accessible information on the nature of the risks and guidance on appropriate use of the models.

Implementation of this option should also be closely coordinated with MSGIC, which promotes coordinated development and efficient use of resources among all entities involved in the collection and use of spatial data and GIS technologies in Maryland.

Related Policies/Programs in Place

Over the past several years, the State of Maryland has directed substantial efforts toward advancing the state's understanding of SLR and coastal hazard vulnerability. The foundation of this understanding has been the implementation of an aggressive strategy dedicated to advanced technology and data and research acquisition and support.

SLR Vulnerability: Recent data and research efforts of the DNR include the completion of historic shoreline position maps; the statewide calculation of historic erosion rates; a comprehensive inventory of shoreline features and conditions for Maryland's coast; and an SLR economic cost study. Another achievement for the state is the acquisition of LIDAR high-resolution topography. Over a 5-year time span, DNR worked with state and local partners to acquire high-resolution topographic data for the majority of the state's coastal counties including all of the Eastern Shore. This data is now being used to develop SLR inundation models that demonstrate the impact of gradual SLR inundation over time, as well as impacts associated with increased storm surge from episodic flood events. SLR modeling has been completed for Worcester County (http://www.dnr.state.md.us/Bay/czm/wcslrreport.html), Dorchester County, and pilot areas within Anne Arundel and St. Mary's counties. Recently, SLR Vulnerability Maps have been created for all coastal counties, depicting lands (i.e., 0 to 2 feet, 2 to 5 feet, and 5 to 10 feet) above mean sea level.

Maryland Shorelines Online (MSO): To provide ready access to the data and information discussed above, the Maryland Coastal Program, in cooperation with Towson University (TU), developed the MSO Internet portal (http://shorelines.dnr.state.md.us/). The portal provides information and tools to coastal managers and decision makers, educators, and the public on SLR, coastal hazards, and shoreline management. This Web site houses information regarding Maryland's legal framework, permitting and regulatory guidance, educational materials, assessments, and spatial decision support tools for shore erosion and SLR. The tools provided on the Web site allow for the identification of potential shoreline protection and restoration options throughout the state to mitigate hazards and enhance natural shoreline habitat. MSO is currently undergoing a comprehensive update to incorporate new information and data.

Coastal Bays Hazards Initiative: In February 2004, the Coastal Bays Policy Committee charged the DNR Coastal Program with the task of assembling a work group to investigate the need for and opportunities for better coordination of coastal hazards issues. In particular, recommendations were to be developed on how to promote the use of new tools and developing technologies at the local level to assist in visualizing hazards and local vulnerability.

Recent developments in data gathering, information management, and planning tools have crossed technological thresholds, which greatly enhances the ability to use desktop planning for hazard response and mitigation. To achieve the efficiencies offered by these new technologies and tools, a better understanding is needed of local government technology requirements, of mechanisms for increasing coordination, and of how to leverage available resources. This Final Report identifies some of the hurdles to implementation and lays the groundwork for expanding application of the products and tools statewide. Specific recommendations in the Report focus on the means for incorporating, developing, processing, and formatting data for decision makers; identifying capacity-building opportunities and needs; recognizing responsibilities and coordination; and providing technical support and financial assistance.

Floodplain Map Modernization: The MDE Business Plan for Map Modernization (2004–2008) outlines the state's vision for updating flood studies throughout Maryland by using FEMA's Digital Flood Insurance Rate Maps (DFIRMS) as a base line. Maryland's objectives for floodplain management have been realigned to coincide with the newer digital floodplain maps being prepared in most of the state. MDE plans to reduce costs and review times associated with traditional detailed studies by maintaining or integrating the FEMA flood studies as a continuously updated model that can be modified as watershed conditions change. Proposed changes (i.e., new roads, bridges, and development) can be added to the flood model to keep the FEMA flood maps current as permits are issued by MDE.

MDE, along with FEMA and local government partners for select counties, initiated the floodplain map modernization project in 2005. Products for Montgomery, Harford, Frederick, and St. Mary's counties have been completed; Baltimore County and Baltimore City are currently pending completion; and Wicomico, Dorchester, and Somerset counties will be completed by the end of 2008. Howard, Anne Arundel, and Cecil counties are scheduled for completion in 2009. Allegany, Washington, Carroll counties and a new Chesapeake Bay Storm Surge Model are planned for 2010. Garrett, Washington, and Talbot counties are expected to be complete in 2011. Completion of products for the remaining counties will depend on the availability of FEMA funding.

Surge Inundation Mapping: LIDAR data were also used by the USACE to develop surge inundation models for Maryland's Eastern Shore counties. These counties are the lowest areas in the state, and some areas are experiencing significant growth pressures. The maps are essential in expanding our knowledge of potential impacts and identifying vulnerable communities and infrastructure. These maps have been provided to local comprehensive planning and emergency management offices. Extension of these mapping efforts into all coastal counties is needed and under consideration.

Local Hazard Mitigation Plans: In November 2004, the MEMA completed the Maryland State Hazard Mitigation Plan (SHMP) and associated mapping pursuant to regulations established by the Disaster Mitigation Act (DMA) of 2000. The goal of SHMP is to reduce the loss of life and property damage associated with hazard events in Maryland. MEMA complied with this priority, because considerable effort has been put forth to map state-owned and critical facilities, as well as the areas for 11 other hazards. The most important aspect of this mapping effort was the identification of facilities, total populations at risk, and vulnerable populations at risk within hazard areas. The data sets and mapping effort will continue to evolve and improve, as new data and technologies become available. MEMA considered historic shoreline changes data during the development of SHMP, which was then used by local governments as the baseline or starting point of information for local hazard mitigation planning activities.

Hazards U.S. –Multi-Hazard (HAZUS-MH): Hazards U.S. (HAZUS) is a risk assessment software program for analyzing potential losses from floods, hurricane winds, and earthquakes. Hazards U.S.-Multi-Hazard (HAZUS-MH) estimates damage before or after a disaster occurs and takes into account various social and economic impacts of a hazard event. MDE partnered with Salisbury University (SU) to complete a statewide analysis of flood vulnerability estimated through the HAZUS-MH flood module. The Level One analysis, completed in June 2005, estimates flood damage from a 100-year coastal or riverine flood event to commercial and residential properties. This study takes the next step after identifying flood vulnerability to understanding the risk to the built environment. The final report, "An Assessment of Maryland's Vulnerability to Flood Damage," is now available.

Emergency Management Mapping Application (EMMA): EMMA was developed by TU University Center for Geographic Information Science (CGIS) in cooperation with MEMA. EMMA is an incident response tool the emergency management community can use to display relevant information before, during, and after an incident occurs. As a Web-based mapping application, EMMA enables the emergency responders to identify incident locations from the field, generate location-specific reports, visualize incident locations via a map, perform site-specific analysis, and coordinate response efforts. Using a simple Web browser, such as Internet Explorer, EMMA provides basic and advanced tools for map visualization, location analysis, and report generation.

Sea, Lake and Overland Surges from Hurricanes (SLOSH): SLOSH is a computer program available to the emergency management and planning communities and is used in the state and local emergency operations centers to identify storm-surge impacted areas and determine evacuation routes. SLOSH, a computerized model developed by the National Hurricane Center (NHC), helps Maryland's emergency management and response communities estimate storm surge heights and winds resulting from historical, hypothetical, or predicted hurricanes by taking into account a storm's pressure, size, forward speed, track, and wind velocity . During tropical Storm Isabel, communication of the surge predictions from SLOSH for the Chesapeake Bay were not accurately translated and transferred to the public.

Hurricane Evacuation Tool (HURREVAC): HURREVAC is a computer program that is available to the emergency management and planning communities through the NHC. HURREVAC automatically tracks hurricane-related information and displays the results graphically. The program is used in the state's Emergency Operations Center (EOC) at MEMA to help determine evacuation options and routes. HURREVAC uses current and forecast storm data and displays the track of the storm in various formats. The program derives the potential for storm surge and calculates evacuation times based on storm speed and intensity. It can also be used as a "what-if" tool to help decision makers determine courses of action for different storm characteristics.

Coastal Inundation Prediction System (CIPS): CIPS is being developed by a team of government, academic, and industry partners through the Chesapeake Bay Observing System (CBOS) of the Mid-Atlantic Coastal Ocean Observing Regional Association (MACOORA) within the Integrated Ocean Observing System (IOOS) to improve the accuracy, reliability, and capability of flooding forecasts for tropical cyclones and nontropical wind systems (e.g., nor'easters) by modeling and visualizing expected on-land storm-surge inundation along the Chesapeake Bay and its tributaries. CIPS will provide an end-to-end prototype of inundation forecasting system to facilitate decision making for emergency management in the challenging case of complex coastlines—semi-enclosed, coastal bays, and estuaries. An initial prototype was developed for the tidal Potomac River in the Washington, DC, metropolitan area. The Chesapeake Bay component was initiated in October 2007, with an expected completion date of 2010.

Maryland State Geographic Information Committee (MSGIC): MSGIC promotes coordinated development and efficient use of resources among all entities involved in the collection or use of spatial data and GIS technologies in Maryland. Most recently, MSGIC focused on interoperable practices and standards, which relate to the "capability to communicate, execute programs, or transfer data among various functional units in a manner that requires the user to have little or no knowledge of the unique characteristics of those units" (MSGIC Web site). The Maryland Mapping Resource Guide (MMRG) lists projects addressing parcel mapping, tax maps, emergency management support, floodplain mapping, and other projects, including several at the county level.

Maryland Statewide Basemap: Maryland Statewide Basemap (*i*Map) will provide access to standardized information (e.g., imagery, roads, streams, place names, and property information) that will serve as a base on which to overlay other data, such as the locations of features or resources at risk from SLR or predicted water levels from storm surge modeling. Anticipated deployment of Phase I is Spring 2008.

Maryland Department of the Environment Wetlands and Waterways Program: The program provides guidance materials, sample drawings, regulations, permit applications, and supporting information on wetlands and waterways. Databases are maintained on wetland gains and losses for regulatory programs, including all types of shoreline stabilization practices, and voluntary restoration and preservation practices, with a focus on marsh creation. Consolidated wetland map layers are also available.

Estimation of Adaptation Benefits and Costs

This option builds on ongoing efforts to integrate and disseminate GIS information collected by local, state, and regional entities and proposes expansion of the available modeling and mapping information relevant to SLR and associated coastal hazards. Integration of the diverse, relevant spatial data, increased monitoring information, refined risk-modeling capabilities, and improved accessibility of information is required to ensure the full benefits of many adaptation options and other planning goals. Greater accessibility of spatial information combined with regularly updated modeling and risk mapping will facilitate the integration of climate change–related information into existing decision-making and planning processes. These tools offer benefits that help inform a wide array of planning initiatives for individuals, public, and private entities and help with assessment of risks and policy options. While information is crucial to some analyses and benefits are likely to be substantial, the benefits of the inputs to a decision are difficult to empirically assess separately from future decisions and uncertainties.

The option requires more detailed assessments in several areas to inform a cost estimate. Research needs include determination of an appropriate maintenance schedule for updating mapping and modeling; assessment of the status and capabilities of mapping and modeling efforts; review of institutional data management practices to enhance efficiency and coordination; and development of pertinent data sets and modeling tools. Development of a financial strategy will depend on findings of these studies and a determination of the adequacy of cyber-infrastructure to ensure easy assess to information.

Feasibility Issues

This option involves a capacity assessment of agencies and cyber-infrastructure. Full implementation and benefits will depend on funding to address any needs identified in the assessment. Flood hazard maps need to be updated regularly to ensure that planning and regulatory actions using these data sets are based on the best available information.

Status of Group Approval

Unanimous

Barriers to Consensus

None.

FBEI-8. Green Economic Development Initiative

Option Description

"We must transition from a carbon-based economy to a green, sustainable economy…" — *Governor Martin O'Malley testimony before the U.S. Senate Environment and Public Works Committee (EPW), September 2007.*

A bold, simple vision that unites diverse interests, when supported by a plan, resources, and tangible results, can inspire Marylanders to meet the challenges of today and tomorrow. The observed and projected impacts of climate change provide ample reason for Maryland and the United States to shift toward a green, sustainable economy. A green economy will involve the greenhouse gas (GHG) mitigation efforts necessary to avoid the increasingly severe impacts associated with greater change and the adaptations required in responding to the current climate-change commitment created by past and ongoing emissions.

While some fear climate change as inhibiting economic prosperity and development, more businesses recognize solutions to climate change may actually create significant economic opportunities while solving other societal problems. The Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report (2007), Working Group II Report "Impacts, Adaptation and Vulnerability, Section 20 states "Sustainable development can reduce vulnerability to climate change by enhancing adaptive capacity and increasing resilience. At present, however, few plans for promoting sustainability have explicitly included either adapting to climate change impacts, or promoting adaptive capacity." Although green-collar jobs in the energy sectors are more widely recognized, adaptation responses to reduce climate change threats and promote sustainability also offer economic development opportunities.

Solutions to climate change can be smart, win-win strategies that simultaneously address multiple issues for diverse stakeholders. There are many adaptation strategies to reduce vulnerability to SLR and associated hazards. If they are carefully crafted, some adaptation opportunities can also contribute to climate change mitigation efforts and broader goals of environmental sustainability. To realize the promise of such strategies, a green economic development plan for Maryland is needed.

Fortunately, the benefits of creating a green, sustainable economy are substantial and widespread. They include a better quality of life, independence from imported fossil energy, thousands of green-collar jobs, lower operating and maintenance costs for homes and businesses, cleaner and more reliable and resilient power systems, a more dependable and healthy food system, better access and mobility, and significant environmental and health improvements, such as cleaner air and water, open space, pedestrian-friendly communities, and restored habitats.

The goal of this option is to initiate the development and execution of a green economic development plan. The intent is to catalyze a self-reinforcing green growth cycle across all sectors of Maryland's economy. In such a growth cycle, an increasing demand for green products and services sustains a thriving community of green businesses and industries which, in turn, create more jobs, healthy communities, and a cleaner environment. Central to this growth cycle are natural principles, such as turning waste into wealth, resource efficiency, optimizing stakeholder value, and life cycle thinking. Thus, Maryland will meet the challenges of climate change while helping the state shift toward a greener, leaner, more sustainable economy.

Option Design

Targets: Establish Maryland as a leader in the new "green" economy by 2015 by increasing the market value of businesses within the state that provide products or services related to a green, sustainable economy and increasing the amount of investment within the state in products and services related to the green economy.

This option includes new green businesses, as well as the greening of more traditional businesses, to improve their economic, social, and ecological performance. Currently, there is no standard for defining what constitutes a green business or commonly accepted measures of what it means to be "green." However, the growth potential for a green, sustainable economy is likely to be quite large, given the existing opportunities for reducing resource waste, pollution, and ecological impacts. Using the state government as a "pump primer" will save taxpayers money by reducing waste, while encouraging the growth of green service and product providers. Finally, while the exact percentage of Maryland's economy considered green is difficult to discern, it is generally understood that the green portion is relatively small, but the demand for green growth is substantial.

There are many barriers to any new technology, and many of those barriers are created by those who profit from the status quo. Using public-sector procurement and publicly supported resources, like academic institutions, to help overcome those barriers is a strategy that has been successfully used by governments at every level. The dominance of American microelectronics throughout the latter half of the twentieth century is attributable in some significant measure to early support by the U.S. Department of Defense (US DOD), just as Europe's current dominance in renewable energy technology is attributable to government incentive programs.

Parties Involved:

Climate change response and economic development efforts will influence a wide array of people and organizations and relate closely to the broader agenda of sustainability. This partial list of parties identifies agencies, businesses, and environmental organizations associated with climate change responses, coastal areas, and green business initiatives.

Green Business Groups—Maryland Green Community (e.g., Green Drinks, Green Building Institute [GBI], Chesapeake Sustainable Business Alliance [CSBA], Maryland League of Conservation Voters [LCV] and Businesses for the Bay), Maryland Green Building Council (standing commission created by legislature), and Clean Energy Partnership (CEP), a Maryland-based nonprofit that organizes businesses in support of practical solutions to global warming.

Business and Labor Organizations—Local Chambers of Commerce, the Maryland chapter of the National Federation of Independent Business (NFIB), a small business advocacy organization, labor unions, organizations, and the financial community (e.g., banks, investment firms, and pension funds).

State Agencies and Offices—DBED, Maryland Economic Development Corporation (MEDCO), MDE, Maryland Coastal Program (a networked program administered at DNR that includes local, state, and federal partners), MDOT, MDA, DHCD, Maryland Office for a Sustainable Future (OSF) within DNR, Maryland Sustainability Subcabinet, and USM.

County and Local Government Agencies—Baltimore Development Corporation (BDC) and MACo.

Implementation Mechanisms

Building on Governor O'Malley's vision and the momentum of initiatives already in place, the State of Maryland should take immediate steps to capitalize on green economic development potential. The Governor should establish a Task Force or other appropriate group capable of acting quickly to refine implementation and initiate strategies to give Maryland strong capacity to recognize and promote market opportunities arising from climate change adaptation and mitigation requirements. DBED and other agencies with programs in business development and trade promotion should play a critical role in this effort. The first effort of the group will be to determine the capacity of existing efforts to identify emerging opportunities in the area of climate change adaptation and mitigation, support the development of products and ideas, and promote these businesses nationally and internationally. The appropriate group should include strategies to enhance statewide capabilities to the level necessary to act on this group's recommendations. Steps for a task force, or other appropriate body, include advancing strategies to accomplish the following:

- **Build public and business awareness of why a green, sustainable economy is good for Maryland.** This step will stimulate demand for green products and services and the "greening" of businesses across sectors. Use benefits listed under Option Description to track and communicate progress. While developing a green sustainable economy is critical to mitigating the impacts of climate change, the challenges created by SLR, increases in storm frequency and intensity, and the many other impacts of climate change will create needs for innovative processes and the development of new goods and services, as well as open competitive market opportunities.
- **Promote the greening of existing Maryland businesses.** Society is being forced to adapt to the impacts of changing climate, while minimizing long-term threats through mitigation efforts. For businesses, adaptation means improving risk management and innovating for new opportunities by demonstrating and supporting practices and solutions that integrate economic, social, and environmental performance. For instance, a company can reduce its risks, build market share and profits, and cut costs through better environmental management (by reducing waste, pollution, and ecological impact) and the introduction of green products and services. Key actions include recognizing leadership in green business practices; providing education, networking, and outreach; and supporting technology and standards development.
- **Use Maryland government as a "pump primer" for stimulating the growth of a sustainable, green economy.** This includes greening state procurement and work policies to save money, improve worker productivity and morale, reduce waste, improve resource efficiency, and lower or eliminate pollution. Develop a scorecard to measure progress in these and other goal areas.

- **Develop adaptation-decision support services and tools for business.** Develop applications and training programs to help businesses identify the climate change issues most relevant to them and the available adaptation options. Climate change will affect business insurance and financing, product and service development, distribution networks, supply chains, relationships with regulators and local communities, competitors, and customers, and markets. Each of these areas is an opportunity for some businesses to adapt to reduce impacts and for others to expand into a new important sector.
- **Market Maryland as a leader in the green revolution.** Undertake a communications campaign to market Maryland as a "green-collar state" receptive to new green businesses. Take inventory of green initiatives and green enterprises already started within the state. Help these entities collaborate, succeed, and market themselves more effectively. Build on the innovations of other states and governments and promote eco-innovation within the state.
- **Build a green-collar, entrepreneurial workforce through education, training, and outreach.**
    - Education from grade school to university or community colleges can help our society transition to a greener, more sustainable future. People will become more aware of problems and opportunities.
    - For some economic sectors, job retraining will be an important element in helping people adjust to changes in the necessary skill sets.
    - Professional and trade personnel across diverse industries need to be trained on installation and maintenance of technologies and the opportunities and risks associated with climate change.
    - Networking and public outreach will help foster collaboration and help build public support.
- **Consider allocating portions of public pension funds within the state to green or clean technology strategies, within the state's definition of fiduciary duty.** Like public procurement, state and local government pension funds can help foster the development of clean technologies and enterprises. Several state pension funds have made allocations of small portions of overall assets to publicly traded or private equity green technology portfolios. The size of the allocation must be consistent with public, private, and nonprofit funding sources and can play a pivotal role in, for example, retirement funds and mortgages. Consider targeting state pension plans to in-state investments. Investment portfolios should consider risk management related to climate change when investing in insurance providers. State retirement funds should offer opportunities to invest in green industries, technologies, and companies
- **Create an environment to foster green business and markets.** With the proper environment, Maryland could
    - Develop new sustainability curricula and research and development (R&D) programs within the USM;
    - Create a business incubator within the USM to provide technological and business services support and outreach to green businesses;

- ○ Provide tax credits or other tax incentives for green consumers, businesses, and technologies;
- ○ Foster businesses that pursue innovations for more resilient coastal area development—from planning to new technology and design;
- ○ Promote a sustainable trade program that includes capacity for marketing, outreach development, and Web site design and management; arrange sustainable trade delegation itineraries and sponsor conventions;
- ○ Promote and invest in water quality and water conservation technologies that will be adaptive to the stresses of saltwater intrusion, drought, and the potential for an increased number and intensity of severe storms;
- ○ Promote and invest in distributed power systems, such as combined heat and power (CHP), micro-turbines, wind power, and solar power;
- ○ Subsidize the production of cellulosic biomass in the agricultural and forestry industries and partner with Pennsylvania and other states that promote this development path;
- ○ Increase the Renewable Portfolio Standard (RPS) requirements for utilities and broaden the requirement to include energy efficiency along with renewable energy;
- ○ Foster businesses that specialize in emissions brokering, offset credits and allowances, and other economic opportunities generated by Maryland's participation in the Regional Greenhouse Gas Initiative (RGGI) cap-and-trade system (C&T) and provide tradable credits for green buildings, agricultural sequestration, and other GHG mitigation mechanisms under the C&T system;
- ○ Incorporate monitoring and improvement of sustainability performance metrics for state agencies under the new Department of Information Technology (see Governor's 2008 Legislative Agenda), and tie economic incentives to performance;
- ○ Create sustainability "revitalization and incentive zones," similar to, or incorporated within, new Base Realignment and Closure Act Revitalization and Incentive Zones (BRAC R&I; see Governor's 2008 Legislative Agenda) or green business park models; and
- ○ Foster green, eco-industrial parks where collocated businesses benefit from sharing and exchanging resources and by-products (http://en.wikipedia.org/wiki/Industrial_ecology).

- **Create sustainable resource-based industries.** Resource-based industries, such as forestry, agriculture, commercial and recreational fishing, and sportsmen's activities, represent the economic backbone of rural Maryland. These industries are heavily dependent on the health and vitality of the Chesapeake Bay and its tributary ecosystems, which is threatened by SLR and associated hazards (e.g., storm surge, coastal flooding, and erosion). Research should to be conducted within each respective field to identify potential ecological and subsequent economic impacts. The end result should lead to formulating and implementing appropriate adaptation strategies to buffer such effects, as well as identifying potential opportunities for expansion and development within respective fields.

Related Policies/Programs in Place

There is a wide variety of efforts aimed at promoting environmental and business interests. In addition to the federal, state, and local programs mentioned below, further programs are likely to be identified if action is taken on policy option FBEI-2, State Agency Reporting on Response to

MCCC Findings. This policy option complements the GHG mitigation policy option developed by the MCCC's Mitigation Working Group (MWG) titled "Promote Economic Development Opportunities Associated With Reducing GHG Emissions in Maryland" (CC-9) and RRI policy option "Resource-Based Industries—Economic Initiative." (RRI-4)

The federal government is currently supporting an array of green business and green-collar job programs, the majority of which are focused on renewable energy and the broader agenda of sustainability, but they indicate federal support for environmental businesses and jobs. As the adaptation agenda gains greater traction, it is likely to emerge as a new dimension to these efforts, particularly where adaptation and mitigation efforts can be integrated, as in living shorelines management strategies or green buildings. The federal agenda is distributed across several agencies, including the U.S. Department of Commerce (U.S. DOC), U.S. Environmental Protection Agency (U.S. EPA), U.S. Department of Energy (U.S. DOE), the U.S. Department of Agriculture (USDA), and the International Trade Administration (ITA) (http://www.ita.doc.gov/competitiveness/sustainablemanufacturing/USG_PRS_Sustainable_Business.asp). The Energy Independence and Security Act of 2007 included a provision for the U.S. Department of Labor (U.S. DOL) to establish a worker training program in energy efficiency and renewable energy that includes grants to states, to support national research for developing labor market data, and to track workforce trends for energy-related initiatives.

Statewide efforts related to this option fall into these main categories: sustainable energy policy, sustainable environmental policy, economic development supported by university educational initiatives, education and state lead-by-example. Efforts to increase government efficiency provide further support for implementation.

Sustainable Energy Policy

Initiatives focused on sustainable energy policy are establishing programs that offer economic development opportunities. The Maryland Energy Agency (MEA) created the Maryland Strategic Electricity Plan to help the Governor and General Assembly craft a sustainable energy policy for Maryland's future. The 2008 legislative session passed several pieces of enabling legislation that will have a significant impact on energy-related opportunities.

EmPOWER Maryland

EmPOWER Maryland, originally established by the Governor, is now codified and strengthens the state's commitment to reducing electricity consumption 15% by 2015. Utilities will rely heavily on increasing implementation of existing technologies to meet this goal.

Maryland Strategic Energy Investment Fund

The Maryland Strategic Energy Investment Fund will make approximately $40 million a year available to support clean energy programs. It will create economic opportunities by supporting investment in energy efficiency technology, stimulating Maryland's emerging clean energy industry, promoting programs to reduce electricity consumption by low- and moderate-income customers, and sponsoring research on technologies to reduce Maryland's vulnerability to climate change. The fund allows MEA to support traditionally underserved markets by providing below-market financing to encourage energy efficiency investments by homeowners and small businesses. The fund will be financed through the upcoming sale of carbon allowances to power plants as part of the RGGI.

Green Building Standards for Building Financed with State Funds

The General Assembly passed legislation promoting green building technologies in new construction that receives state funding. Maryland will lead by example by requiring that all new schools and significantly renovated state buildings over 7,500 square feet meet the Leadership in Energy and Environmental Design Green Building Rating System™ (LEED) Silver standard.

Renewable Portfolio Standard

To meet growing electricity needs, new legislation commits Maryland to investing in new forms of electricity generation by raising the RPS from 9.5% to 20%. This requirement will create opportunities to increase renewable and clean energy generation.

Solar and Geothermal Tax and Grant Incentives

New tax relief and grant opportunities for solar and geothermal systems are designed to stimulate investment in clean energy and increase supply. These incentives create new economic and employment opportunities by encouraging more investors and households to enter clean energy sectors.

Sustainable Environmental Policy

The Chesapeake Bay is Maryland's most precious natural resource. Approximately $381 million from the fiscal year 2009 budget is designated to provide programs directly related to the restoration of the Bay and its tributaries. Maryland has supported developing expertise in agricultural management programs, which protect the Bay while supporting sustainable agriculture practices and preserving open space. State legislation also supports improved storm-water management and oyster restoration. SLR and associated threats of climate change will exacerbate the threats to the Bay. Thus, skills, knowledge, and technologies developed for environmental management will become increasingly valuable elements of adaptation. The following are other state programs that may support more effective environmental management.

Chesapeake Bay 2010 Trust Fund

The Chesapeake Bay 2010 Trust Fund will ultimately make $50 million available for innovative pollution reduction and cleanup strategies to improve the health of the Bay.

Revisions to the Critical Area Act

Revisions to the Critical Area Act improve administration and enforcement capabilities to protect critical buffers around the Bay.

Transit-Oriented Development

Transit-oriented development (TOD) legislation provides another tool to support smart growth, revitalize communities, and curb sprawl, while offering opportunities to reduce transportation contributions to GHG emissions. International, national, and state trends in efforts to reduce GHG emissions suggest that knowledge and experience in this sector will be increasingly sought after.

Promoting Jobs And Economic Growth

Several new efforts to support education, workforce development, and economic and community growth offer opportunities to promote environmentally friendly technologies and practices. In addition to the programs and policies listed above, there are other initiatives related to renewable energy development (especially ethanol and biodiesel) and business incubators that could support green economic development.

Base Realignment and Closure Community Enhancement Act and Revitalization and Incentive Zones

The BRAC Subcabinet, which coordinates the planning and financial resources of the state government to support the missions of military installations expanding under BRAC, anticipates as many as 60,000 new jobs and 28,000 new households will come to Maryland by 2011. The BRAC Community Enhancement Act includes initiatives to leverage state and private sector investments critical to supporting the community and transportation infrastructure necessary to accommodate BRAC-related growth. BRAC R&I Zones will provide local jurisdictions with incentives to enhance public infrastructure, such as streets, utilities, and recreation venues, in designated revitalization and redevelopment areas in keeping with Smart Growth principles. BRAC Zones will offer incentives to draw businesses into targeted areas of the state in need of revitalization and redevelopment. These incentives may also provide an opportunity to encourage high-quality green businesses to locate in the state. In addition to the BRAC Community Enhancement Act, the Administration will propose to expand the uses of the new Higher Education Investment Fund to allow for BRAC-related initiatives administered by the MHEC. Governor O'Malley has included $3 million in the fiscal year 2009 budget for workforce training initiatives related to BRAC.

Education

The USM has established an Environmental Sustainability and Climate Change Initiative aimed at improving environmental management practices on campuses, supporting state efforts, and providing training in environmental programs. While education programs currently listed are not focused on climate change, they include relevant efforts such as the University of Maryland Center for Environmental Science (UMCES) and the multi-campus graduate program in Marine-Estuarine-Environmental Science (MEES).

State Government Lead-by-Example

The state government can lead by example, as well as foster innovative climate change responses. Programs that were established to increase government efficiency may be used to track these efforts. StateSTAT— a performance measurement and management tool—collects data on important state initiatives to improve accountability and efficiency.

Many policy options proposed here rely on coordination across agencies. The newly created Department of Information Technology will be responsible for information technology policy enabling agency, community, and public access to vast amounts of data and other useful information. This new department will also assume the responsibility for coordinating, purchasing, and managing all telecommunications devices and systems utilized by state agencies. The Secretary of Information Technology will lead chief information officers of all agencies to streamline business processes across state government, achieve cost savings through economies of scale, and coordinate initiatives related to security, disaster recovery, and continuity of operations.

Estimation of Adaptation Benefits and Costs

This policy option focuses on taking advantage of new market opportunities arising from climate adaptation and mitigation needs. The level of benefits will depend on the implementation strategies pursued and their success in the broader competitive market. At a minimum, this option encourages private sector involvement in innovation and development of green economic sectors and jobs. It also broadens the range of entities involved in collecting, evaluating, and responding to climate change and increases the potential for innovation and better adaptation solutions. The mix of these programs can be adjusted relatively quickly and easily to accommodate new information and opportunities, particularly if there is a diverse set of sectors and strategies in the portfolio. Costs associated with this policy option will vary, based on the portfolio of strategies pursued.

Feasibility Issues

This option builds on Maryland's strong base of leadership and expertise in environmental management. There are ideas and technologies ready for further development or adoption, as well as a growing market. Success of this effort depends on funding availability and public and organizational acceptance and support for climate change adaptation and mitigation.

Status of Group Approval

Unanimous

Barriers to Consensus

None.

Acronyms and Abbreviations

ARWG	Adaptation and Response Working Group
BDC	Baltimore Development Corporation
BPW	Board of Public Works
BRAC R&I	Base Realignment and Closure [Act] Revitalization and Incentive [Zones]
C&T	cap-and-trade
CBOS	Chesapeake Bay Observing System
CEP	Clean Energy Partnership
CGIS	[Towson University] Center for Geographic Information Science
CHP	combined heat and power
CIPS	Coastal Inundation Prediction System
COMAR	Code of Maryland Regulations
CRS	Community Rating System
CSBA	Chesapeake Sustainable Business Alliance
CZMA	Coastal Zone Management Act
CZMP	Coastal Zone Management Program
DBED	Department of Business and Economic Development
DBM	Department of Budget and Management
DFIRMS	[FEMA's] Digital Flood Insurance Rate Maps
DGS	Department of General Services
DHCD	Department of Housing and Community Development
DHMH	Department of Health and Mental Hygiene
DLLR	Department of Labor, Licensing and Regulation
DMA	Disaster Management Act
DNR	Department of Natural Resources
DOE	U.S. Department of Energy
EBEI	Existing Built Environment and Infrastructure
EMMA	Emergency Management Mapping Application
EOC	Emergency Operations Center
EPW	[U.S. Senate] Environment and Public Works [Committee]
EX	Climate Change and Global Warming
FEMA	Federal Emergency Management Agency
GBI	Green Building Institute
GGO	Governor's Grants Office [of Maryland]
GHG	greenhouse gas
GIS	geographic information system
GOHS	Governor's Office of Homeland Security
GOSV	Governor's Office on Service and Volunteerism
HAZUS MH	Hazards U.S. Multi-Hazard
HHSW	Human Health, Safety and Welfare
HIA	Health Impact Assessment
HURREVAC	Hurricane Evacuation Tool
IBC	International Building Code

IGIS	integrated geographic information system
*i*MAP	Maryland Statewide Basemap
IOOS	Integrated Ocean Observing System
IPCC	Intergovernmental Panel on Climate Change
IRC	International Residential Code
ITA	International Trade Administration
LCV	League of Conservation Voters
LEED	Leadership in Energy and Environmental Design™
LIDAR	light detection and ranging
LPPRP	Land Preservation Parks and Recreation Plans
MACo	Maryland Association of Counties
MACOORA	Mid-Atlantic Coastal Ocean Observing Regional Association
MCCC	Maryland Climate Change Commission
MDA	Maryland Department of Agriculture
MDE	Maryland Department of the Environment
MDOA	Maryland Department of Aging
MDOT	Maryland Department of Transportation
MDP	Maryland Department of Planning
MEA	Maryland Energy Agency
MEDCO	Maryland Economic Development Corporation
MEES	Marine-Estuarine-Environmental Science
MEMA	Maryland Emergency Management Agency
MES	Maryland Environmental Services
MHCC	Maryland Health Care Commission
MHEC	Maryland Higher Education Commission
MIA	Maryland Insurance Administration
MIEMSS	Maryland Institute for Emergency Medical Services Systems
MML	Maryland Municipal League
MMRG	Maryland Mapping Resource Guide
MPBC	Maryland Public Broadcasting Commission
MSDE	Maryland State Department of Education
MSGIC	Maryland State Geographic Information Committee
MSO	Maryland Shorelines Online
MWG	Mitigation Working Group
NAIC	National Association of Insurance Commissioners
NCMPMS	National Coastal Zone Management Performance Measures System
NERRS	National Estuarine Research Reserve System
NFIB	National Federation of Independent Business
NFIP	National Flood Insurance Program
NHC	National Hurricane Center
NOAA	National Oceanic and Atmospheric Administration
NWS	National Weather Service
OP&R	Office of Preparedness and Response
OSF	Maryland Office for a Sustainable Future

PSC	Public Service Commission
R&D	research and development
RGGI	Regional Greenhouse Gas Initiative
RMC	Rural Maryland Council
RPS	Renewable Portfolio Standard
RRI	Resources and Resource-Based Industries
SHMP	State Hazard Management Plan
SLOSH	Sea, Lake and Overland Surges from Hurricanes
SLR	sea level rise
SRPS	State Retirement and Pension System
STO	State Treasurer's Office
SU	Salisbury University
TOD	transit-oriented development
TU	Towson University
UM	University of Maryland
UMCES	University of Maryland Center for Environmental Science
US DOC	U.S. Department of Commerce
US DOD	U.S. Department of Defense
US DOE	U.S. Department of Energy
US DOL	U.S. Department of Labor
US EPA	U.S. Environmental Protection Agency
USACE	U.S. Army Corps of Engineers
USDA	U.S. Department of Agriculture
USGS	United States Geological Survey
USM	University System of Maryland
VM	Volunteer Maryland

Human Health, Safety, and Welfare

HHSW-1. Health Impact Assessments of the Climate Change Action Plan

Option Description

Policy options that relate to preparing for and responding to climate change may have considerable health consequences for Maryland residents. Therefore, a mechanism is needed to assess the public health consequences of proposed mitigation or adaptation policies and measures before they are adopted. Health Impact Assessments (HIAs) are a proven approach to ensuring that public health concerns are identified and addressed before they become a problem. The World Health Organization describes the value of HIAs in this way: "HIA provides decision makers with information about how any policy, programme or project may affect the health of people. HIA seeks to influence decision makers to improve the proposal." (see http://www.who.int/hia/en).

An HIA should be conducted, at a minimum, whenever an Environmental Impact Statement is required or if a proposed policy is expected to have health-related impacts. HIAs can also be used to identify the co-benefits of smart growth and development policies.

Option Design

HIAs would be required as part of mitigation and adaptation strategy evaluations. This option could be implemented by a legislative mandate that would require a letter sign-off by the Department of Health and Mental Hygiene (DHMH) on proposed mitigation and adaptation policies and measures that need an Environmental Impact Assessment.

The formal process of an HIA involves the following steps:

1. **Screening:** This involves a rapid assessment of whether the policy would require a formal, detailed HIA or a relatively limited assessment. The DHMH would screen proposed policies, and the results would be reported as a recommendation for either a more formal HIA or a limited staff assessment.

2. **Scoping:** If a formal HIA is recommended, DHMH would work with the group that proposed the option and other interested parties to define the objectives of the HIA, key participants, and potential data needs.

3. **Appraisal:** This is the actual analysis. For a given policy option, there might be an analysis of the affected populations, distributional and equity considerations, an examination of health resource requirements, and an assessment of health infrastructure implications. In addition, alternatives would be introduced for reducing or mitigating potential health consequences of the proposed policy.

4. **Monitoring and Evaluation:** During this phase, the adopted policy's implementation would be monitored and evaluated, and corrections would be made as needed to ensure that the policy is effective and that it protects human health.

Targets and Timing: Adoption of HIAs as a formal requirement for policy alternatives for mitigating or adapting to climate change would be implemented immediately, and there would be immediate benefits for the residents of Maryland.

Parties Involved: The DHMH, together with the Maryland Department of Environment (MDE), Maryland Emergency Management Agency (MEMA), and local health agencies, would review proposed policy options according to the HIA framework. Review would be coordinated through the Environmental Health Liaison Committee.

Implementation Mechanisms

No statutory change is required to implement this option, but it would require adoption of an executive policy that provides for conducting HIAs of proposed adaptation or mitigation policies.

Related Policies/Programs in Place

Environmental Public Health Tracking—a project funded by the Centers for Disease Control and Prevention (CDC)—would make environmental and public health data from a number of surveillance programs available on a single Web site. This program could benefit the process of developing HIAs, because it would provide a ready source of historical data and geographic information system (GIS) capability.

Implementing this option would facilitate achievement of the goals of the Healthy Places Act. For example, an HIA was conducted in Georgia for their "BeltLine" policy for transportation and land use (http://www.cqgrd.gatech.edu/HIA).

Adaptation Benefits and Costs

Capital Intensity: Capital is not required for adoption of this policy; however, additional staff time will be required.

Flexibility: HIAs have been shown to increase the flexibility of proposed policy options because they require that policy alternatives be considered.

Adaptive Capacity: This proposal would increase the adaptive capacity of state institutions by incorporating consideration of possible public health considerations at the beginning of the policy process, rather than waiting for adverse consequences to be recognized and mitigated at the end of the process. Further, recognizing possible adverse health consequences early on results in preventing injuries and illnesses before they occur and also results in less costly solutions. In addition, the cross-department and agency collaborations developed as a result of HIAs increase the capacity of the state to prepare for and respond to climate change risks.

Documentation of Adaptation Benefits and Costs

Data Sources: Information on HIAs is available at http://www.cdc.gov/healthyplaces/hia.htm. Data needed for HIAs within the state will be obtained from DHMH, MDE, Maryland Department of Natural Resources (DNR), MEMA, and other agencies.

Quantification Methods: HIAs would require some staff time and some data on environment and health, which should be available through environmental public health tracking and other sources.

Key Assumptions: There is an assumption that HIAs would be mandatory for climate change policy evaluation, as well as (in the future) for other major development policies.

Key Uncertainties: There are no uncertainties associated with implementing this policy option.

Additional Benefits and Costs

An additional benefit of HIAs is the potential beneficial impact on the planning process in general. As health benefits (and costs) are taken into account in evaluating development and planning projects, the state stands to make better decisions regarding growth that benefits current and future residents.

Feasibility Issues

The major feasibility issues are the sufficiency of the data and the level of involvement of interested parties. The major successes for HIAs have been in communities with considerable input into the process and a range of potential options from which to select.

Status of Group Approval

Unanimous

Barriers to Consensus

None.

HHSW-2. Coordination Across Agencies Responsible for Human Health and Safety

Option Description

A gap analysis will be conducted to determine whether management, procedures, and coordination of county- and city-level options are adequate for ensuring consistency in and capacity for adaptation and response to health-related impacts of climate change across boundaries. For example, coordinated responses may be required for large-scale floods and storms to ensure the safety and protection of drinking water sources and septic systems/waste treatment and in the event of infectious disease outbreaks. One response might be ensuring adequate planning and implementation for extreme or wet-weather events that could affect surface- and groundwater water quality, wastewater, and human health. The Code of Maryland Regulations (COMAR) and/or county codes may need to be modified for drinking water supplies that require a well to protect the health of populations and the Chesapeake Bay from increasing saltwater intrusion due to climate change. Septic system requirements in COMAR and/or county codes may need to be modified because of the increased risk of groundwater elevation from sea level rise.

The gap analysis would be coordinated with the 2008 Federal Gap Analysis, as applicable. Recommendations resulting from the analysis will recognize and account for differences in response capacity between counties, and mitigation and augmentation options will be recommended to minimize disruption in services due to lack of capacity.

Option Design

Targets and Timing: The principal target organizations include DHMH, local health departments, MEMA, MDA, MDE, and the Maryland Institute for Emergency Medical Services Systems. The gap analysis would require approximately 2 months to plan, 8 months to conduct, and 2 months to evaluate and finalize.

For example, one conclusion of the analysis might be that counties and municipalities should be encouraged to adopt well and septic provisions, update Water and Sewer Plans, and re-map zoning for areas that are at-risk for inundation due to flooding or tidal and storm surges. Requiring denitrification of septic systems in critical at-risk areas, and modification of septic systems in areas that are prone to low groundwater tables, should be a consideration for maintenance of water quality and public health and safety. Several counties have recently passed laws for denitrifying septic systems in at-risk areas.

Counties will need to use watershed-level planning—land use planning, building codes, and land easements and acquisitions—for an integrated approach to sea level rise.

Parties Involved: See Targets and Timing.

Implementation Mechanisms

The DHMH Office of Preparedness and Response (OP&R) would lead the gap analysis in cooperation with MEMA and other target agencies. Components of the gap analysis are (1) organization of the response, (2) benchmarking (from external best practices), (3) capacity inventory, (4) information technology and communications, (5) needs analysis, and (6) state law and policy amendments.

Related Policies/Programs in Place

OP&R already has continuity of operations (COOP) plans in place for many aspects of DHMH operations and has worked with local health departments on their COOP plans. Critical issues, such as personnel capacity to respond to large-scale events, have been discussed in a number of forums, including the Environmental Health Liaison Committee.

Other programs that may require review and/or amendment are

- Source Water Assessment Program (SWAP). The Safe Drinking Water Act, as amended in 1996, requires all states (MDE manages this for Maryland) to develop and submit plans to the U.S. Environmental Protection Agency (EPA). Source Water Protection is voluntary under federal law, but the state could require that the Program be adopted in specific areas www.mde.state.md.us/Programs/WaterPrograms/Water_Supply/sourcewaterassessment/index.asp
- Fish Consumption Advisory (from MDE) for mercury and other contaminants (www.mde.state.md.us/CitizensInfoCenter/FishandShellfish/hom/index.asp
- Reporting and Public Notification of Sewage Overflows (from MDE) (www.mde.state.md.us/ResearchCenter/Publications/General/eMDE/vol1no4/overflows.asp)
- Emergency Planning and Community Right-to-Know Act (EPCRA) for Hazardous Substances (www.epa.gov/oem/content/epcra/index.htm)

Adaptation Benefits and Costs

Capital Intensity: Capital is not required for adoption of this policy.

Flexibility: The gap analysis will identify barriers and constraints to response. Overcoming the barriers will increase the state's flexibility in responding to large-scale events.

Adaptive Capacity: This policy option would increase the adaptive capacity of state institutions by increasing coordination and collaboration among the various entities and by raising awareness of how to appropriately address the health risks of climate change.

Documentation of Adaptation Benefits and Costs

Data Sources: The gap analysis will require consultation with all participating agencies. Best practices for interagency coordination will be consulted, including those enumerated in the CDC's TIIDE project (Terrorism Injuries: Information, Dissemination and Exchange), available at: http://www.bt.cdc.gov/masscasualties/modelcommunities.asp

Quantification Methods: Standard gap analysis techniques will be employed.

Key Assumptions: The gap analysis will involve a considerable amount of dedicated staff time from several agencies. The potential for contributions of technical expertise, funding and other resources from the private sector is unknown.

Key Uncertainties: None.

Additional Benefits and Costs

The gap analysis will benefit all aspects of agency operations and coordination, as well as specific responses to climate change.

Feasibility Issues

Feasibility is critically dependent on interagency coordination.

Status of Group Approval

Unanimous

Barriers to Consensus

None.

HHSW-9. Vector-Borne Surveillance and Control Programs

Option Description

One of the consequences of climate change that has received considerable attention is the likelihood of changes in patterns of vector-borne diseases. As the climate warms, the geographic range of several insect- and arthropod-borne diseases is likely to expand northward.

The DHMH, in close cooperation with the Maryland DNR and the Maryland Department of Agriculture (MDA), has responsibility for conducting vector-borne disease surveillance and control programs such as the West Nile virus surveillance program that tracks mosquitoes and cases of human infection. This option would entail development of a coordinated plan to ensure adequacy of the surveillance program, given increased demand resulting from climate change.

Option Design

Targets and Timing: A working group will be created that includes members from each department responsible for vector-borne surveillance and control to develop a coordinated plan to ensure adequacy of programs.

Significant increases in personnel and resources may be required if surveillance of vectors and cases is to be expanded. Vector surveillance requires collection of specimens, laboratory analysis, and GIS or other spatial analysis in order to follow the physical distribution of the vector. These tasks require specialists capable of specimen collection, laboratory resources, and data management capacity. The long lead-time required to recruit and/or train the personnel to fill these specialized positions necessitates advance planning and dedication of resources. For example, some positions may take more than a year to fill. The lack of trained entomologists could be addressed by providing university scholarships.

Parties Involved: MDA, Maryland DNR, and the DHMH would be involved in developing a coordinated plan. In addition, those agencies would collaborate with other agencies responsible for water storage and storm water management to ensure that these programs achieve their goals without increasing the number of breeding sites for disease-carrying vectors.

Implementation Mechanisms

The policy option would create a working group involving all of the departments that would prioritize and identify the resources required to meet the increased demands associated with climate change.

Related Policies/Programs in Place

There are currently vector and disease surveillance programs within the state that could meet some (but not all) of the demands associated with increased monitoring of vector-borne diseases. The MDA provides mosquito control services in cooperation with participating county governments (www.mda.state.md.us/plants-pests/mosquito_control/mosquito_control_policy.php). The preferred mosquito control strategy is the reduction of mosquito larvae numbers by source reduction, use of biological control agents, or use of biological insecticides. Adult mosquito control, by ultra-low-volume application of insecticides is conducted by using aircraft or truck-mounted application equipment in residential areas for nuisance abatement and to protect the public from mosquito-borne disease.

The aim of the U.S. Department of Agriculture (USDA) Veterinary, Medical and Urban Entomology National Program is to reduce the risk to humans from arthropod-borne and zoonotic diseases (http://www.ars.usda.gov/research/programs/programs.htm?NP_CODE=104).

The U.S. Fish and Wildlife Service has a mosquito management policy (http://www.fws.gov/policy/library/E7-20201.html. The National Wildlife Refuge System has a draft mosquito and mosquito-borne disease management policy (http://cc.msnscache.com/cache.aspx?q=73540470571274&lang=en-US&w=c499b04c,87053e86).

The use of integrated vector management and the use of the least toxic pesticides necessary to achieve the desired results should be included in this option. There are also techniques such as organic landscaping for storm water management that should be evaluated in light of the need to control breeding grounds for certain disease vectors.

The working group would provide outreach to programs, such as those promoting a green economy, to ensure that the risks of vector-borne diseases do not increase with changes in infrastructure and landscape management.

Estimation of Adaptation Benefits and Costs

Capital Intensity: The capital requirements relate to funding for the additional personnel needed to meet the demands identified by the working group. There may be some additional capital requirements for specialized trapping equipment related to vector surveillance or to increase laboratory capacity.

Flexibility: This policy option allows flexibility because it entails the option of using personnel involved in surveillance activities to perform multiple functions or to switch to different surveillance activities if the impacts of climate change differ from projections.

Adaptive Capacity: This option provides the state with considerable capacity to adapt to the effects of climate change. Both the personnel and laboratory capacity anticipated will be able to perform multiple functions which will allow the state to shift resources in a relatively narrow window.

Documentation of Adaptation Benefits and Costs

Data Sources: For best practices, recommendations were from the Council of State and Territorial Epidemiologists (CSTE), as well as the CDC Emerging Infectious Disease program (http://www.cdc.gov/ieip/); recommendations from the World Health Organization are available at: http://www.who.int/heli/risks/vectors/vectordirectory/en/index6.html.

Key Uncertainties: None

Feasibility Issues

The primary feasibility issue relates to the state's ability to recruit and retain the personnel required to carry out surveillance activities.

Improving surveillance and control activities should include educational programs so that individuals do not over-spray when vector-borne diseases are identified. Using excessive amounts of insecticides has adverse health and environmental consequences.

Status of Group Approval

Unanimous

Barriers to Consensus

None.

Acronyms and Abbreviations

CDC	Centers for Disease Control and Prevention
COMAR	Code of Maryland Regulations
COOP	continuity of operations [plans]
CSTE	Council of State and Territorial Epidemiologists
DHMH	[Maryland] Department of Health and Mental Hygiene
DNR	[Maryland] Department of Natural Resources
EPA	U.S. Environmental Protection Agency
EPCRA	Emergency Planning and Community Right-to-Know Act
GIS	geographic information system
HIA	Health Impact Assessment
MDA	Maryland Department of Agriculture
MDE	Maryland Department of Environment
MEMA	Maryland Emergency Management Agency
OP&R	Office of Preparedness and Response
SWAP	Source Water Assessment Program
USDA	U.S. Department of Agriculture

Public Awareness

Public Awareness, Outreach, Training, and Capacity Building

Option Description

Sea level rise and increases in the frequency and intensity of flooding, storms, and storm surges are expected to have complex and far-reaching consequences for residents, businesses and trades, and local governments. Better preparation, through modification of existing strategies and policies and implementation of new ones, will reduce the impacts experienced by Maryland's citizens. A key component is increasing awareness of the risks and appropriate responses among those responsible for preparation and response—the media, non-governmental organizations, and others—as well as those likely to be affected. It is important that all stakeholders be identified, along with their specific educational, outreach, training, and capacity-building needs.[1]

Communicating the potential risks of and responses to climate change will be an essential part of implementing the recommendations from all policy options identified by the Adaptation and Response Working Group (ARWG). Two basic activities are needed: development of coordinated and cohesive communication messages, and effective distribution of the messages to a wide variety of people and professionals across all levels of government, sectors, and organizations. For example, plans for addressing the needs of property owners in coastal counties will differ from plans to ensure that mental health needs are addressed during and after a disaster. Of particular concern is the development of communication plans to reach low-income and underserved populations.

Education, training, and outreach programs are needed for those in the public health sector so they can better decide what actions to take during and after an event to reduce the potential for outbreaks of vector-, food- and waterborne diseases from contaminated recreational water. Efforts to educate health care providers and the public on the signs and symptoms of these diseases will improve detection and treatment.

Vulnerable infrastructure needs to be protected from storm surges and serious or frequent flooding events. The building and development community needs to be made aware of and to

[1] Outreach—is an effort by an organization to connect its ideas or practices to the efforts of other organizations, groups, specific audiences, or the general public.

Training—refers to the acquisition of knowledge, skills, and competencies as a result of the teaching of practical skills and knowledge.

Technical assistance—professional and direct assistance intended to provide guidance to organizations or individuals to conduct or strengthen specific management objectives.

Capacity building—a comprehensive suite of tools to strengthen the abilities, behaviors, and skills of individuals and improve institutional structures and processes such that the organization can effectively meet its mission and goals.

understand how to implement new building codes that have been adopted for reducing losses. Local governments need to understand how to implement and enforce new polices. Shoreline changes resulting from sea level rise and coastal hazards could impact a broad group of constituents, and it is important that landscapers, mortgage brokers, and property owners, for example, understand those impacts. Incorporation of climate change risks into formal training programs for individuals entering businesses likely to be impacted by climate change would ensure a strong capacity to address these issues in the future.

Option Design

This policy focuses on integrating information on climate change risks and risk management strategies into existing and ongoing educational, outreach, training, and capacity-building programs and supports the creation of new programs as needed. Coordination will be needed to ensure efficiency and coherence across these programs.

Targets:

- Establish a framework for consistent communication within 1 year of implementing this option.
- Develop climate change risk communication training with Public Information Officers of germane agencies to ensure clear and consistent messaging and prevent contradictions in messages and warnings. The Network for Education of Municipal Officials (NEMO) could be used as the template.
- Develop educational programs on appropriate behavior before, during, and after extreme events. Identify and engage all current licensing, training, and capacity-building programs in areas at serious risk from sea level rise and extreme weather events. Work with industry professionals, people who live or work in these areas, and others to identify gaps in public awareness, training, and capacity building.
    - Recommend specific policy and program changes that will enable these groups and programs to respond to future training and capacity needs in a manner best suited to their respective involvement in activities related to risks from sea level rise and extreme weather events.
    - Continue to provide training and public awareness opportunities and capacity-building assistance, but begin to offer more targeted support to populations and areas that will be most seriously affected.
- Ensure that education, outreach, training, and capacity-building programs specifically address the needs of low-income and underserved populations.
- Increase the ability of at-risk residents, businesses and trades, and local governments to understand the risks, gather the information they need to make informed decisions, and work with partners to identify solutions.
- Develop educational programs to increase awareness of the risks of vector- and waterborne diseases in a warmer climate that may result from climate change.
- Contact landowners to make them aware of wetland and forest protection programs (e.g., land easement and/or purchase programs).

- Conduct outreach to marine contractors to train them in the design and implementation of innovative shore erosion control strategies.
- Conduct outreach to communities to inform them of the most current design and construction standards for erosion control structures and tidal shoreline habitat enhancement projects.
- Disseminate information from the assessment of potential climate change impacts on resources-based industries.
- Ensure access to outputs from Option RRI-1, New Criteria for Identifying Natural Resources Priority Protection Areas [RRI = Resources and Resource-Based Industries]. This option would include using geographic information system (GIS) tools to assess target areas for strategic action. Outputs would include maps that identify areas most vulnerable to sea level rise. Access to these maps could be made available on a public Web site to increase awareness of the risks of sea level rise.

Timing:

- Recommend that all counties have Citizens Emergency Response Teams within 2 years.
- Increase the number of training programs and capacity-building efforts in areas most at risk over the next 5 years.
- In areas most at risk, convene a multidisciplinary group to identify risks and possible responses for public health, disaster management, building trades, and others. For building trades, review building codes and other regulations to identify and adopt necessary changes over the next 10 years and incorporate these activities into licensing training procedures.

Parties Involved: Parties involved include Maryland Department of Natural Resources (DNR), Maryland Department of the Environment (MDE), Maryland Department of Health and Mental Hygiene (DHMH), Maryland Department of Labor, Licensing and Regulation (DLLR), Maryland Emergency Management Agency (MEMA), NEMO, the Governor's Office of Community Initiatives, the Governor's Office on Service and Volunteerism, local governments, Citizens Emergency Response Teams, property owners, business and trade members in industries affected by sea level rise and climate change, church-based groups, and non-governmental organizations.

Implementation Mechanisms

Implementation of this recommendation would require a coordinated effort by a number of existing agencies or departments, groups, organizations, and programs. One approach would be to assign a staff member from MEMA to participate on the Governor's Sustainability Sub-Cabinet. The Maryland Municipal Leaders and the Maryland Association of County Officials also could play a significant role in implementation, possibly including sponsoring a yearly event focused on education.

Successful implementation would require an investment in staff time and funding to complete a review of current training and capacity-building programs or delivery options; identify mechanisms through which new or revised programs would be most likely to succeed; and create or update policies and regulations.

Publish a real estate disclosure brochure on the risks associated with climate change.

Related Policies/Programs in Place

This option supports all the policy options identified by the ARWG; without effective education, training, outreach, and capacity building, the general public will have insufficient understanding and motivation to support implementation of the policies needed to protect the state and its residents and businesses.

Examples of existing policies and programs include

- The Maryland DLLR's Division of Occupational and Professional Licensing, Maryland Home Improvement Commission (MHIC) provides a variety of licensing services required by the state to industry professionals.
- The Maryland Coastal Program and other coastal and shoreline groups that serve the Chesapeake Bay deliver technical and financial assistance, data tools, and training opportunities to groups such as property owners, local and state governments, marine contracting professionals, and other networked partners.
- The MDE Wetlands and Waterways Program provides technical assistance, guidance and educational materials, and training on wetland/waterway regulatory issues, wetland conservation and management, shoreline management, floodplain management, and local floodplain ordinance development and implementation.
- The Chesapeake Bay National Estuarine Research Reserve's Coastal Training Program leads training events for professional coastal decision makers on a variety of coastal- and climate change-related issues in cooperation with a network of partners.
- The Maryland DHMH provides outreach to health professionals on vector-borne diseases. In addition, the Office of Preparedness and Response works with local health departments and the MEMA on public preparedness efforts.
- Other organizations and programs also coordinate with industries and groups concerned with the health and safety of citizens to provide training, public awareness programs, and capacity building.

Estimation of Adaptation Benefits and Costs

Incorporation of the risks of climate change and sea level rise into educational, outreach, training, and capacity-building programs for individuals, businesses, organizations, and agencies will increase Maryland's effectiveness in addressing these issues in the future and in incorporating new information into its mitigation and adaptation approaches.

Status of Group Approval

Unanimous

Barriers to Consensus

None.

Acronyms and Abbreviations

ARWG	Adaptation and Response Working Group
DHMH	[Maryland] Department of Health and Mental Hygiene
DLLR	[Maryland] Department of Labor, Licensing and Regulation
DNR	[Maryland] Department of Natural Resources
GIS	geographic information system
MDE	Maryland Department of the Environment
MEMA	Maryland Emergency Management Agency
MHIC	Maryland Home Improvement Commission
NEMO	Network for Education of Municipal Officials
RRI	Resources and Resource-Based Industries

Resources and Resources-Based Industries

RRI-1. New Criteria for Identifying Natural Resources Priority Protection Areas

Option Description

This option provides the technical and scientific foundation for developing and testing new and existing criteria for identifying priority protection and restoration areas, in the context of sea level rise (SLR). The assessment will focus on identifying undeveloped lands and ecologically and economically important land and aquatic areas (including important habitats and marsh migration corridors) critical for targeted conservation and coordinated restoration, in response to SLR and its associated effects. The assessment will also address the future distribution and condition of underwater habitats and resources, such as Submerged Aquatic Vegetation (SAV) and oyster beds. This information will be fed into other policy options to strategically and cost-effectively direct and implement specific conservation, restoration and growth management actions.

Rising sea level will impact coastal ecosystems and natural resource lands. These resources provide important ecosystem services and benefits. Coastal resources support wildlife habitats, have regional significance for migratory birds, sequester large amounts of carbon, provide sediment and nutrient water quality and flood control benefits, and generate economic benefits through farming, forestry, fishing and passive recreation. Preserving undeveloped, vulnerable lands offers a significant opportunity to avoid placing people and property at risk to SLR and associated hazards, including storm surge, coastal flooding, and erosion.

As sea levels rise, various future conditions are possible. As an example, tidal marshes, beaches and dune habitats have the potential to: migrate landward if there are no barriers to migration, such as roads and buildings or other unsuitable physical factors; or become eliminated if the opportunity to migrate landward is blocked, or the rate of migration is exceeded by the rate of SLR. Identifying where these resources are, how important they are for various ecosystem values and economic services, and what the likely impact of SLR will be provides the basic information needed to plan for the protection and management of coastal natural resources. Existing assessments should be used to develop geographic information systems-based (GIS) and modeled criteria. These criteria should be ground-truthed and enhanced by additional field-based criteria.

The objective of this option is to identify target areas where strategic management actions, identified in other policy options, can be focused to buffer against the impacts of SLR and other climate changes. These actions may include expanding the priorities for existing land conservation to promote horizontal marsh migration, risk reduction and other land use goals. Other actions may focus on appropriate areas for restoration or rehabilitation projects, such as sand and sediment replenishment to fuel the vertical growth of wetlands, barrier removal or other coastal ecosystem and land management practices.

Option Design

Targets:

- Identify high priority ecological and economic natural resource lands and aquatic habitats in the coastal zone (a condition assessment) using existing assessments and any additional enhancements or additions necessary to address data gaps for considering the effects of SLR.
- Identify coastal land areas important for wetland migration corridors, for maintaining ecosystem integrity and connectivity, to support farming, forestry and fisheries industries and to confer risk reduction to coastal communities, in response to projected SLR inundation and coastal flooding scenarios (a functional assessment).
- Determine through conserved lands and protective zoning overlays where high priority coastal lands are currently protected and where strategic conservation and forest and wetland restoration targets should be identified.
- Develop a peer-review method for modeling wetland migration resulting from SLR.
- Develop a set of field-based criteria that considers effects of SLR and climate change to further identify the suitability of lands for protection or restoration, in order to ensure eligibility for implementation programs.

Timing: Within the first year, develop a scoping plan for conducting the study which will determine how to use and tie together existing information to identify protection and restoration priorities in relationship to SLR, and to determine what data gaps and modeling efforts need to be addressed for a comprehensive analysis. Other components of the scoping plan includes developing a timeline to include initial assessment using best available information (Phase I), additional assessments as new data, models and criteria are developed (Phase II), and determining the level of staffing and funding resources needed to complete each phase of assessment.

Implement the assessment plan over the following 2 years, provided technical resources can be secured. Phase I implementation can include an initial and coarse level assessment of resource priorities, current level of protection, and resource vulnerability to SLR using results from existing resource assessments and SLR projections.

Field studies may need to be conducted to develop and test criteria for determining the site-scale suitability of various restoration practices in response to SLR. The suite of restoration practices includes wetland restoration and marsh migration projects, reforestation using salt-tolerant species, SAV and oyster bed restoration. The criteria would inform the likelihood of success and the necessary design specifications of the project. The timing of this would be dependent on the programs being concerned with adaptation responses, as detailed in other policy options.

Parties Involved: The Maryland Department of Natural Resources (DNR), Maryland Department of the Environment (MDE), Maryland Department of Planning (MDP), University of Maryland (UM), and other technical and scientific organizations should complete the resource assessment, threat analysis, and model development.

MDP should specifically evaluate the degree of current protection of vulnerable lands targeted as conservation and restoration priorities, through local and state growth-management controls.

MDE and DNR should specifically evaluate the degree of protection, through regulatory mechanisms (Tidal and Non-tidal wetland regulations and Critical Area regulations).

Implementation Mechanisms

Implementing this recommendation would require the investment of staff and funding to complete the analysis, conduct any needed specialized studies and document and publish the results. Potential funding mechanisms that could be explored include of the Clean Water Act's Section 309, the Coastal Zone Management Act (CZMA), and Coastal Enhancement Strategies dealing with coastal hazards. A National Oceanic and Atmospheric Administration (NOAA) Coastal Zone Management fellowship could also be pursued to recruit the staffing expertise needed for developing the first year plan and focusing on Phase I implementation.

Related Policies/Programs in Place

Existing natural resource assessments can be used, in concert with other modeling and mapping efforts. In addition, existing conservation priorities, such as DNR's Priority Conservation Areas, those identified in Maryland's Coastal and Estuarine Land Conservation Plan (CELCP), and other agency conservation targets.

Existing resource assessments and conservation priorities include the following:

- The Green Infrastructure Assessment identifies an ecological hub and corridor network across the state, prioritizes for ecological value, and is a DNR foundation for focusing conservation and restoration work;
- The Blue Infrastructure Assessment specifically focuses on aquatic values and the aquatic and terrestrial interface, surveys aquatic, wetland, and shoreline natural resources, identifies areas of highest ecological and economic value, and currently under development by DNR;
- Strategic Forest Lands Assessment is a DNR project that identifies forested areas of highest ecological and economic value;
- Prioritizing Sites for Wetland Restoration, Mitigation, and Preservation in Maryland by the MDE uses GIS to map, target, and rank opportunities for wetland restoration, mitigation, and preservation for habitat and water quality benefits;
- Maryland Shorelines Online (MSO) is a DNR Web site that provides a digital GIS survey of shoreline condition (e.g., built, soft or hard stabilization, naturalized), erosion rates, and habitat benefits, and GIS-based SLR inundation areas are also available on the site; and
- SLR projections, elevation assessments, and inundation maps provided by DNR.

Maryland Department of Natural Resources Priority Conservation Areas: DNR's Program Open Space (POS) has identified landscapes with high ecological value (based on Green Infrastructure and other resource assessments) and designated these areas as Priority Conservation Areas. POS then focuses in on a subset of these areas to target its ecologically based land conservation objectives.

Maryland Department of Planning Priority Preservation Areas: These areas have been identified, as required through the 2006 Agricultural Stewardship Act (House Bill 2; 2006), as high priority, agricultural resource lands, and will be the targets for agricultural land-preservation programs.

Other Studies and Programs

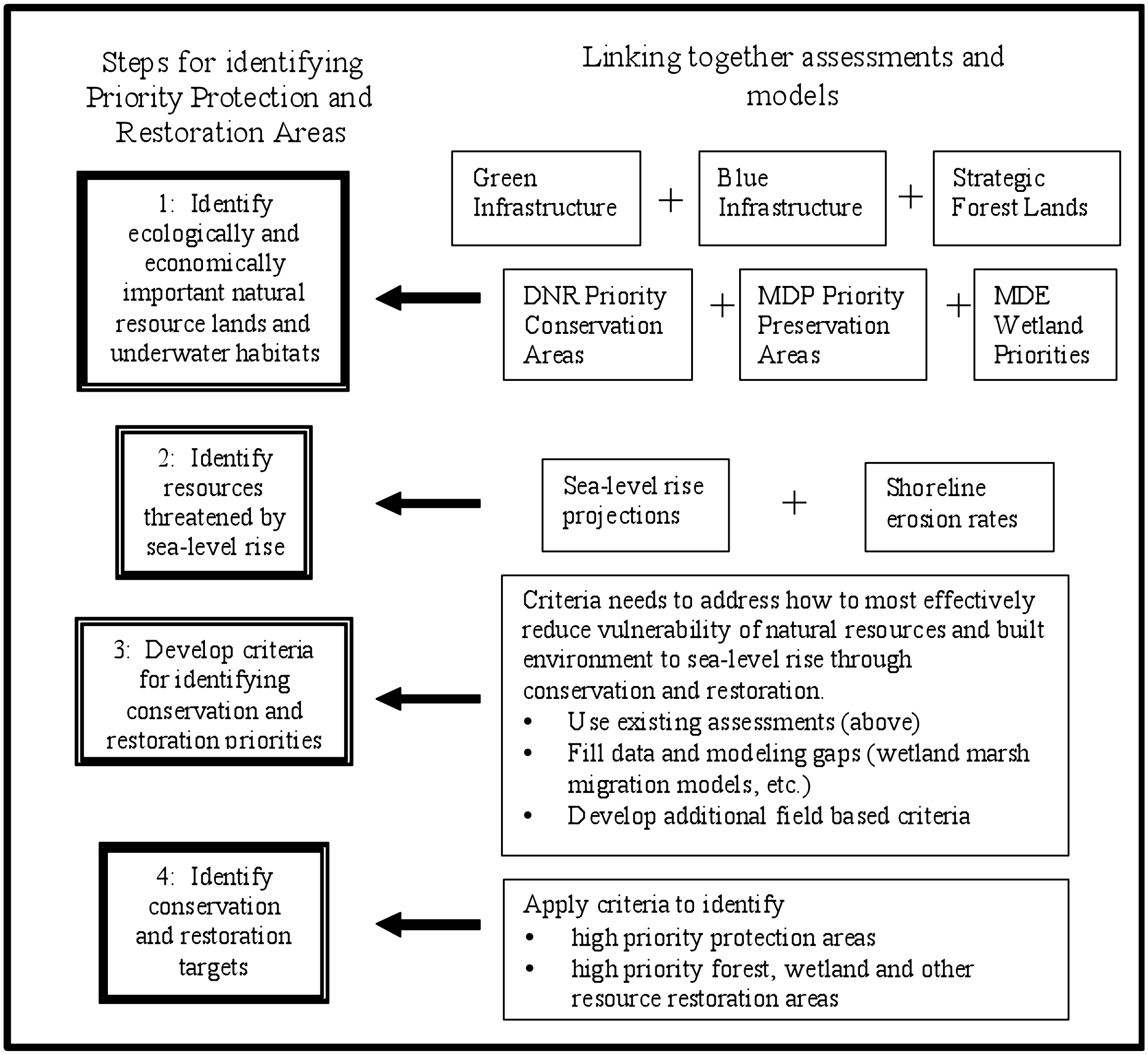
Restoration of Blackwater National Wildlife Refuge marshes—This is an ongoing study that is building up degraded marshes through sediment replenishment and marsh grass plantings. Marsh accretion and carbon sequestration is being intensely monitored at this site, and will provide the basis for field and modeled criteria and factors for determining suitable marsh migration corridors and restoration sites (UM, U.S. Fish and Wildlife Service [US FWS], DNR, MDE, and Constellation Energy).

*Sea Level Affecting Marshes Model—S*ea Level Affecting Marshes Model (SLAMM) is a modeling effort funded by the U.S. Environmental Protection Agency (EPA) first developed in the mid-1980s and currently being refined as Version 5. Results for the Chesapeake Bay will be available by mid-2008 and were funded by The National Wildlife Federation (NWF).

Integration Strategy

A framework diagram will illustrate how these various assessment and models could be linked together to determine the location of high priority natural resource conservation and restoration areas.

Figure I-1. Outline of proposed approach



Estimation of Adaptation Benefits and Costs

The costs associated with implementing a program of identifying priority areas for strategic management actions will be incremental to those already incurred to develop and maintain existing natural resources assessments. These incremental costs fall into four major categories: staffing, assessment, equipment, and maintenance. The primary cost associated with this option involves recruiting dedicated staff to develop the scoping plan and conduct the resources assessment. Assessment costs involve the costs associated with developing and testing new methodologies and criteria for prioritizing protection areas. Equipment costs involve the costs associated with any new equipment (e.g., gauges) and software (e.g., database management) required to complete field studies. Finally, there will likely be a set of annual costs associated with the maintenance of physical equipment and database systems.

The benefits associated with identifying priority protection areas center on the flexibility this information offers to other programs that seek to implement strategic actions to protect against the anticipated impacts from SLR.

Feasibility Issues

Inadequate staffing and funding resources largely hinder implementation feasibility. For the first year, one full-time staff member at DNR would need to be dedicated to the development of the resource assessment plan, to coordinate the necessary peer review required to approve and move forward with the plan, and to direct early action analysis. The analytical steps outlined in the flow diagram could be separated into two work phases.

Early Action Phase: The technical assessments needed to complete Steps 1 and 2, are complete, except for the Blue Infrastructure Assessment (completion date targeted for December 2008). Preliminary analyses to coarsely identify resources at risk could begin immediately if dedicated staff time and expertise could be identified for technical analysis and technical direction.

Project Coordination And Final Product Phase: Significant review and coordination with relevant scientific and technical expertise needs to be initiated within the next year to begin the development of criteria and the identification of model and data gaps (Step 3). Technical direction and documentation of the final product, listed as Step 4, is also needed. This will require the funding and dedication of one full-time staff person, in addition to other staffing and resource investments needed to complete the comprehensive identification of high priority protection and restoration areas.

Status of Group Approval

Unanimous

Barriers to Consensus

None.

RRI-2. Forest and Wetland Protection

Option Description

Use enforcements, financial incentives, and educational outreach to retain and expand forests and wetlands in the coastal zone, and other areas subject to storm surge and SLR, to enhance adaptive response to climate change. The aim of this option is to develop actions to prioritize expansion and retention of working forests and wetlands in areas suitable for long-term survival and ambient land-use. The expected benefits of this option include protection from shoreline erosion, reducing peak runoff during storm events, and avoiding stranded infrastructure. The forest and wetland protection option for adaptation and response builds upon the Mitigation proposal and analysis done by the Agriculture, Forestry, and Waste Management (AFW) Technical Work Group (TWG), especially AFW-3 and AFW-4.

Critical Areas, buffers, and other non-urban, future impact areas will be targeted for forest establishment and expansion, based on elevation and landscape planning. Future forest and wetlands areas will provide replacement zones for wildlife migration and movement corridors. Research efforts are needed to develop more water and salt tolerant plant species as SLR impacts move inland. Forest conservation incentive policies will be increased in targeted areas emphasizing not only preservation and expansion, but also forest management issues that optimize forest health.

There will be multiple climate-change benefits, as these forests and wetlands will continue to sequester carbon until called on to provide a critical storm barrier. Water and air quality, wildlife habitat, and many other natural resource improvements will be immeasurable side benefits of implementing this option. Increased forests will provide local needs for renewable resources, such as wood products for construction, pulp, and fuels, and the demand for which will also increase.

Option Design

Targets:

- From RRI-1, use the new criteria for identifying priority protection areas to identify priority forest and wetlands for protection. Potential areas to target for forest and wetland expansion and protection include undeveloped areas within 1000 feet of mean high tide (current Critical Area definition), floodplain areas in the coastal zone, and areas prone to saltwater intrusion. Already developed areas will consider appropriate opportunities for setting and realizing tree canopy goals, establishing rain gardens, and promoting other means of green infrastructure to simulate the benefits of intact forest and wetlands.
- Develop, package, and market new and existing incentive programs to landowners for ease of targeting protection and restoration.
- Future impact areas, based on elevation mapping, become priority forest retention and establishment areas. Lower areas are more suitable for salt-tolerant woody species or for wetland establishment, especially where connected to existing wetlands.

- Create and augment dedicated sources of local funding, such as through ballot initiatives, for the conservation of forests and support these through state matching grants (see New Jersey model below).
- Identify and develop programs to enhance and protect migration corridors, from shorelines to inland habitats, and maintain connectivity of forest core areas across the landscape.
- Provide officials and staff to better enforce existing laws such as Critical Areas.

Timing: The program will be implemented in 2009, due to the need to establish and conserve forested areas as soon as possible. This will maximize the benefits of the new forest or wetland prior to their need as replacement habitat. An intensive public relations effort will begin prior to full implementation (2008–2009) to the citizens of Maryland, but particularly to the citizens of future impacted areas of the SLR issue, and the values of promoting and enhancing forest areas. This program should run indefinitely (continuous), and be evaluated regularly for effectiveness and when new information becomes available.

Parties Involved: DNR, Maryland Department of Agriculture (MDA), and MDE will be lead agencies involved in the implementation of various tasks under the program. Technical assistance infrastructure is already in place, especially for restoration, through cooperative programs, such as the Maryland Forest Service, Soil Conservation Districts, and Agriculture and Forestry Extension Agents, as the on-the-ground contact for landowners. DNR and MDA can provide some promotional staff and resources to identify and target contact areas. There is also considerable overlap with existing federal programs, including those of the Natural Resources Conservation Service (NRCS). Numerous national, regional, and local private-nonprofit organizations also conduct and support land protection (e.g., land trusts) and wildlife enhancement activities (e.g., wildlife and waterfowl habitat restoration groups). Maryland legislature would have to approve new incentives for land protection.

Other: County and local governments must become involved in this endeavor, in promotional and implementation efforts, including land-use planning and zoning efforts.

Implementation Mechanisms

Identification of priority working forests and wetlands to protect will be implemented, as identified in the mapping and analysis exercise described in RRI-1. In order to protect these priority lands, it is expected that Maryland will use a mix of increased tax benefits, easements from willing landowners, creative local financing and acquisition, and other incentive programs. The reason to invest in these lands is to avoid the costs of inundation in the built environment, and to avoid the economic and environmental costs incurred by losing these resource lands.

For restoration of riparian forest buffers and wetland restoration, this option can be implemented through existing and ramped-up Farm Bill programs, such as the Conservation Reserve Enhancement Program (CREP) and the Wetlands Restoration Program (WRP), as well as the Chesapeake Bay Restoration Act Funds. There may be untapped opportunities to use Farm Bill programs and funds to promote forest restoration. But forest conservation and restoration incentives are currently limited, and overshadowed by those provided for protection of farmlands. Additional staffing and funding will be needed as current on-the-ground and support resources for forests and wetlands are minimal at this time compared to the past (reductions in funding and staff), and compared to what would be needed to fully implement this Option.

One researched mechanism to greatly increase available funds for land conservation without additional expenditures by state government is known as the New Jersey Model. In this Model, local governments in Maryland are enabled to post ballot initiatives to create a dedicated source of funds to protect forests and wetlands. Recent polling shows that a wide majority of Maryland voters would support such an initiative. Concurrently, state legislation would be passed to provide matching funds to those funds raised by local governments. This mechanism would conservatively generate four times the current available funding for land conservation without spending additional state funds.

Related Policies/Programs in Place

- Maryland's Forest Conservation Act
- Critical Areas Law
- Maryland's POS, including Rural Legacy, uses funds garnered through realty transaction taxes to acquire priority land. Land has not been prioritized according to SLR, but includes other criteria, such as scenic value and lands beneficial to water quality.
- National-level policies such as the Coastal and Estuarine Land Protection Act and Forest Legacy, and conservation acquisition programs supported by The Nature Conservancy, The Conservation Fund, and other non-governmental environmental groups
- State-level programs such as Chesapeake Bay Trust and Maryland Environmental Trust (MET), and programs supported by organizations like the Chesapeake Bay Foundation (CBF), 1000 Friends of Maryland.
- Various programs supported by local and regional land trusts, watershed organizations (planning, networking, and education function), and other non-governmental groups.
- Chesapeake Bay Program (CBP) water quality cap maintenance goals, under the Sound Land Use goal area of *Chesapeake 2000,* are goals for identifying and protecting valuable resource lands. Since 2000, these goals have been better defined and geographically targeted (e.g., 2007 Forest Conservation Directive [conserve forests for water quality and riparian forests, expand use of tree canopy goals] and the Chesapeake Action Plan [due out in 2008]). There currently is no CBP goal for wetland protection.
- Farm Bill programs offer conservation practices, such as riparian and shoreline afforestation (CREP) and wetland enhancement (WRP), that provide short-term easements of 10 to 30 years, and permanent easements in the case of the Farm and Ranchlands Protection Act. At this point, the latter program excludes forestlands and wetlands, except where they are incidental to farms.
- MDE Wetlands and Waterways Program protects wetlands primarily through a regulatory program and by direct compensatory wetland mitigation to targeted areas, as identified in MDE's *Priority Areas for Wetland Restoration, Preservation, and Mitigation* and *Priority Areas for Wetland Restoration, Preservation, and Mitigation in Maryland's Coastal Bays,* and their amendments. Funding for restoration and enhancement of wetlands is available for

state wetland programmatic mitigation projects, and through MDE's Water Quality Infrastructure Program (WQIP).

Estimation of Adaptation Benefits and Costs

The costs of conserving and restoring forests and wetlands are associated primarily with capital costs of acquiring easements on the land identified as critical to buffering against the impacts of SLR. These costs vary according to the implementation mechanism, or range of mechanisms used. As noted above, some federal and local funding may be able to assist the state in this regard. However, in order to serve as an incentive to landowners, funding must be increased to be comparable with land values for development. In addition to acquiring easements, there are incremental costs associated with dedicating agency staff to managing conservation and restoration programs.

Maintaining healthy coastal forests and wetlands will provide many important ecosystem services to the state, including protection from shoreline erosion, reduction of peak runoff during storm events, protection of water quality, and carbon sequestration. These functions of forests and wetlands directly benefit aquatic and terrestrial ecosystems by preserving habitat for native and migratory species, which in turn support the resources that sustain recreational and commercial endeavors.

Feasibility Issues

- Proposed changes to the Critical Areas definition increases the initial bandwidth in select areas on which one cannot develop from 100 feet to 200 feet. This may cause confusion and a rush-to-develop in the short term, but in the long term will be helpful for adapting to climate change.
- Legislative issues are to identify and maximize targeted landowner incentives, and get them approved, and to pass enabling legislation that allows for local ballot measures to create dedicated funding for local land protection.
- The mapping product from RRI-1 may not be available at the initial stages of implementing this option. However, this option may use MDE's wetland targeting maps as a starting point, which reflect current assessments, but do not consider vulnerability to SLR.
- Technical and economic feasibility issues need to be addressed on a case-by-case basis. Proposed projects need to be ranked according to their technical merit and economic impact, which would assess the expected value and risk of a range of strategies. Considering specific actions and locations will be a necessary step in evaluating which projects receive the highest priority for support.
- Implementation of certain mechanisms is subject to increased funding available to landowners for restoration and protection projects.
- There may also be social feasibility issues caused by pressure to develop in areas vulnerable to SLR.

Status of Group Approval

Unanimous

Barriers to Consensus

None.

RRI-3. Sustainable Shorelines and Buffer Area Management Practices

Option Description

Shoreline erosion is a significant issue facing Maryland's diverse coastal environment. Approximately 70% of Maryland's 7,700-mile shoreline is experiencing some degree of erosion, which will worsen as a result of increased rates of SLR, and increased frequency and intensity of coastal storms from climate change. Comprehensive shoreline management must be an integral part of any future erosion control planning effort, and should aim at striking a balance between protection against erosion and preserving natural shoreline processes and habitats. Natural shorelines are essential for maintaining and promoting important aquatic and terrestrial habitats, trapping sediment, and filtering pollution. An increased understanding of non-structural and structural erosion control alternatives at the practitioner level, new mapping resources, regulatory guidance, shoreline inventories, and Web-enabled analytical tools are now sufficiently in place to facilitate such plans. Adopting a collaborative state-local approach to developing such plans will maximize the odds of success in designing and implementing a specific shoreline erosion control practice that achieves a balance between protecting land and minimizing disruption to the coastal environment.

The recommendation for a unified approach to shoreline management was presented in the "Interim Report to the Governor and the Maryland General Assembly: Climate Action Plan." As a direct result, two bills were introduced and passed in the 2008 Maryland General Assembly. The first, the Living Shorelines Protection Act of 2008 (HB 973), directs erosion control projects to consist of nonstructural shoreline stabilization measures that preserve the natural environment, such as marsh creation, except in areas mapped by the state (MDE and DNR) as being appropriate for structural stabilization measures. There is also a provision that it is the responsibility of the property owner to demonstrate to MDE's satisfaction that such nonstructural measures are infeasible. The second strengthens the Chesapeake and Atlantic Coastal Bays Critical Area Protection Program (HB1253/SB844). In general, the changes: provide a greater authority to the Critical Area Commission; update the basic components of the program, including the Critical Area boundary; enhance buffer and water quality protection; coordinate new development more closely with Smart Growth principles and other environmental protection and planning processes; and strengthen enforcement and variance provisions. Implementation of these legislative actions will require coordination across multiple levels of government (e.g., state, local or county, municipality), recognizing that each level of government will need to address these from different aspects.

In addition to moving the new legislation forward, this option focuses efforts on filling in any remaining gaps and should incorporate the following elements:

- A reorientation of DNR's Shoreline Conservation and Management Program (formerly the Shore Erosion Control Program) to promote the installation of innovative shore protection techniques that maximize habitat restoration and enhancement, and accommodate for projected SLR.

- Develop a general permit that streamlines the rebuilding process of storm-damaged tidal marshes, including the placement of additional clean, sandy fill, plants, and temporary biodegradable structures to protect rebuilt areas. Currently, introducing clean, sandy fill material requires a state permit, while simple planting of wetland species on existing substrate in the correct hydrologic and salinity regime does not. Repairs would be authorized under guidelines issued by the MDE.
- A requirement directing a joint effort of state agencies to standardize design and construction methods and protocols employed for shore-erosion control structures—new and retrofit—that consider climate adaptive strategies for coastal environments subject to SLR, erosion and storm hazards. Guidelines should be developed and tailored for specific target audiences, including marine contracting professionals, government officials, and public citizens.
- Expand current outreach and education programs directed at the public and marine contracting professionals to help ensure a smoother transition toward broader implementation of nonstructural and hybrid techniques. Using up-to-date protocols mentioned previously, contractors may receive training about the design and installation of proven control practices that may also maintain or enhance coastal processes and habitats. Contractor training will increase the likelihood of successful installations and boost property owner confidence in the benefits of increased state oversight. A certification program, in cooperation with the Maryland Home Improvement Commission (MHIC), should be considered as part of the implementation of this element.
- Integration of mapping and modeling products into state and local planning and implementation efforts. This should include a mechanism to update the Maryland Comprehensive Shoreline Inventory (CSI) to include type and quantity, location, and conditions of shore erosion control structures, on the order of every 5 to 10 years. This could be linked to the permitting process, in order to create a system for automatic entry and updates to the database for projects being proposed and implemented.

Option Design

Targets:

There are four key targets associated with this option, as outlined below:

1. Implement statutory changes passed during the 2008 General Assembly.

2. Work with an interdisciplinary team with expertise in wetlands, coastal processes, biology, restoration, and coastal erosion control design and engineering to standardize design and construction protocols for erosion control structures and tidal-shoreline habitat enhancement projects.

3. Distribute modified and new design and construction standards to engineering, contractor, local governments, non-governmental organizations (NGOs), and property owner communities. Appropriate training will be developed for engineering and contracting outfits, in order to transfer critical information about the design and installation of these innovative techniques.

4. Development of a strategy for updating the CSI every 5 or 10 years.

Timing: Adopt required regulatory changes in October 2008; promulgate guidance manuals and attendant training programs by 2009; have a strategy for updating CSI in place, with the first subsequent update by 2010; following CSI update, initiate shoreline management plans in 2011, with target completion date for plans by 2013.

Parties Involved: Critical Areas Commission, MDE, and DNR.

Other: Resource Conservation and Development agencies; local governments in the coastal zone; Board of Public Works (BPW), Wetlands Administrator; engineering, contracting, and property owner communities; U.S. Army Corps of Engineers (USACE) and other federal resource management agencies; the Center for Coastal Resources Management (CCRM) of the Virginia Institute of Marine Science (VIMS); and others.

Implementation Mechanisms

Implementation of this option will include a combination of executive, legislative, and programmatic actions. The first step is the promulgation of regulation to implement statutory changes passed during the 2008 Maryland General Assembly. Second, updated design and construction standards and protocols for Shore Erosion Control (SEC) structures—new and retrofit—should consider climate adaptive strategies for coastal environments subject to SLR, erosion, and storm hazards. These guidelines should be distributed to the engineering, construction, and property owner communities, via state agencies, county planning offices, and Resource Conservation and Development agencies.

Additional programs that would support the implementation of this option could include professional development programs for contractors and permit reviewers to establish a quality control mechanism, revitalizing and expanding the financial assistance program through DNR's Shoreline Conservation and Management Program, and expanding outreach and education programs for local governments and waterfront landowners.

Related Policies/Programs in Place

A number of state and federal sponsored activities and programs that are related to this option are currently underway, including:

- The DNR's *Shoreline Conservation and Management Program* (formerly the SEC Program), provides subsidies and technical assistance for non-structural projects to Maryland property owners in resolving shoreline erosion problems along the Chesapeake Bay and its tributaries
- The *Comprehensive Coastal Inventory Program* (CCI), through the CCRM at the VIMS, has developed shoreline situation reports for CSI, which include land use, bank conditions, and shoreline features (including erosion control structures). The inventory captures baseline shoreline conditions throughout the tidal portions of Maryland's coastal counties. The CSI can be used as a state and local planning tool to inventory and assess coastal infrastructure vulnerable to SLR inundation or coastal flooding.
- The *DNR,* through various programs, is conducting SLR and storm surge mapping.
- The DNR's *Green and Blue Infrastructure Assessments* (Blue Infrastructure is still under development).

- *Strategic Shore Erosion Assessment (SSEA)*—from 2000 to 2002, a NOAA Coastal Services Center Coastal Management Fellow worked with the Maryland Coastal Program to initiate the development of a comprehensive approach to shore erosion planning for Maryland. The Fellow was tasked with developing a protocol to create regional strategies to deal with shoreline erosion issues. The Fellow worked closely with two counties, Dorchester and St. Mary's, to identify an approach to balance the need to address risk from erosion, while maintaining natural shoreline habitat
- The Maryland Coastal Program in conjunction with VIMS, the USACE and MDE, is participating in the development of *Erosion Vulnerability Assessment* (EVA) as a component to the Chesapeake Bay Shore Erosion Control Feasibility Study and Master Plan. This assessment is designed to evaluate stretches of shoreline and prioritize these areas for erosion control activities. The outcomes of the project will include outreach material for marine contractors and homeowners, and a guide for potential shore erosion management activities for various government agencies
- The Maryland Coastal Program and VIMS are creating the *Living Shorelines Suitability Tool* for Worcester County that identifies areas not suitable for living shoreline treatments, those that are suitable and those that may be suitable with design restrictions. This tool is slated for completion in September 2008
- The *Living Shorelines Stewardship Initiative* (LSSI) is a collaborative effort by various public and private entities to promote the use of "living shorelines" (i.e., vegetated buffers) to waterfront property owners
- *DNR's Coastal Program* has collaborated with MDE and contractors that currently install "living shorelines" to offer outreach and education workshops for marine contractors and homeowners. Among other aspects, these courses focus on the designs, installations, permitting, and benefits of "living shorelines."
- MDE prepared guidance, the *Shore Erosion Control Guidelines: Marsh Creation*, as shore erosion control practice and habitat benefit. These guidelines were developed based on completion of an MDE-funded study to UM. Fact sheets are also available on contractor selection, practice selection, maintenance, and marsh creation
- *Maryland Department of the Environment Sample Drawings,* developed for marsh creation projects, based on results and recommendation of a UM study. Drawings include marsh as a stand-alone project, as a hybrid project with a supporting sill, and marsh creation in conjunction with existing bulkheads.
- *Shore Erosion Control Guidelines for Waterfront Property Owners 2nd edition*, MDE's update of its 1992 publication, addresses latest guidance for structural and nonstructural practices. The document will be completed in 2008 and will include latest regulatory requirements to address 2008 legislative additions for shoreline management and preference for marsh creation. To be completed in 2008.

Estimation of Adaptation Benefits and Costs

Costs for this option could include additional financial support to upgrade MDE's permit database for improved tracking of shore erosion control projects, as well as incremental costs associated with managing a program to update the CSI. An increased demand for "living shoreline" training and outreach programs, such as those conducted by the Chesapeake and Coastal Program at DNR and the Wetlands and Waterways Program at MDE, is expected. Additionally, DNR's Ecosystem Restoration Services will likely see an increase in shoreline property owner requests for technical and financial assistance for implementation of nonstructural shore protection practices.

Shore erosion will be exacerbated as a result of rising sea levels, and as such shore erosion control projects will continue to be in demand as a means of protecting coastal property and infrastructure. The increases in demand for these projects will likely result in positive economic impacts to the marine contracting industry, given that adequate professional training is provided to shift those outfits that have historically installed hardened structures.

Developing clear guidelines for the design and implementation of shoreline erosion control practices has distinct benefits. As noted above, implementing this option increases the odds of success in achieving a balance between protecting the land and minimizing disruption to the coastal environment. Thus, the benefits can generally be viewed as the avoided costs of property damage from storm events and the maintenance of ecosystem services provided by natural shorelines, which include sediment trapping and pollution filtering.

Feasibility Issues

The need to address professional development opportunities for the marine contracting industry is a key issue of the feasibility of this recommendation. At present, there are limited marine contracting companies capable of designing and installing these innovative and nonstructural approaches to shoreline erosion control. Many companies have focused on structural erosion control techniques, such as riprap and bulkheads. To help ensure a smoother transition toward broader implementation of nonstructural and hybrid techniques, additional offerings of contractor training are a logical approach. The DNR's Maryland Coastal Program has collaborated with MDE and contractors that currently install "living shorelines" to conduct a limited number of training sessions to address this emerging need. However, more training is needed to transfer critical information about the design and installation of proven control practices that may also maintain or enhance coastal processes and habitats. Additional training will increase the likelihood of successful installations and boost property owner confidence in the benefits of increased state oversight.

Status of Group Approval

Unanimous

Barriers to Consensus

None.

RRI-4. Resource-Based Industry—Economic Initiative

Option Description

Resource-based industries such as forestry, agriculture, commercial and recreational fishing, and sportsmen's activities represent the economic backbone of rural Maryland. These industries are heavily dependent on the health and vitality of the Chesapeake Bay and its tributary ecosystems. While potential climate change impacts to these industries are widespread (e.g., changes in salinity, temperature, rainfall, disease, invasive species), SLR and associated hazards, such as storm surge, coastal flooding and erosion, threaten areas where the current primary land use supports these industries. Comprehensive adaptation response strategies that investigate all possible impacts should be addressed, recognizing that many will fall outside the focus of this phase of adaptation planning.

Baseline information regarding the impacts of climate change, including SLR and associated coastal hazards, on the economics of varying sectors of resource-based trades and industries is lacking. Research within each respective field should aim to identify these potential impacts, and lead to developing an appropriate strategy to buffer such effects as well as identifying potential opportunities for expansion and development. State agencies, in cooperation with the private sector, should focus efforts on the development of long-range plans (i.e., fishery management plans, forestry management plans, marine sensitive areas initiatives, and agriculture land use plans) flexible enough to adjust to ongoing and future change. Such plans should be developed in ways consistent with local land use master plans, and foster small local mills and farms. This option addresses protection mechanisms to minimize the economic impacts of climate change on natural resource industries, or adaptation by the use of new non-conventional methods.

Fisheries-Based Industries

The total estimated value of the Maryland seafood industry is $700 million, with $207 million generated by commercial fishing and crabbing activities. There are 73 processing plants employing 1,360 people and over 6,000 watermen who work the Chesapeake Bay, which account for $1.76 billion in wages. Impacts to this industry due to climate change are largely unknown, mainly due to the uncertainty attendant to climate change effects on aquatic habitats and populations. Resource populations (i.e., crabs, oysters, and finfish) and the associated industries are already under stress due to present land-use practices, overfishing, degradation and loss of nursery habitat, and extensive inshore and coastal pollution. Conserving habitat and diversity is a present challenge, and SLR may further aggravate habitat fragmentation. Additionally, not knowing what population and species changes will follow makes it difficult to predict what could replace the current economic engine for which Maryland is famous. Concern over species and habitat shifts is real and likely not amenable to mitigation through traditional planning. Long-range plans for these resources will have to be innovative, and should consider all aspects of the seafood industry. This includes, but is not limited to, areas such as: the methods in which the resource populations and associated habitats are managed; processing, packaging and distribution practices; and aquaculture practices, in order to streamline costs and maximize profits while ensuring sustainability.

Management efforts should focus on conserving a diversity of habitats to maintain functionality and persistence of populations, so they can be resilient during times of stochastic climate conditions and associated coastal hazards. Significant opportunities for industry development might exist within the aquaculture field. Maryland currently produces a wide variety of aquatic fish, shellfish and plants, the value of which was nearly $3.4 million in 2003. Research is needed to determine whether there are additional populations that could be supplemented, restored in the wild, or generated simply for supply.

Forestry-Based Industries

Maryland's forest products industry is a $2.48 billion industry, considered to be the largest industry in Western Maryland and the second largest industry after agriculture on the Eastern Shore. The long-term profitability of the forest products industry is directly linked to a sustainable-forest resource base and stewardship of forests and forestlands in a way that maintains their potential to fulfill relevant ecological, economic, and social functions to ensure the future health and usefulness of the forest. Forests, like other open space areas, are under intense development-related pressures for residential, commercial, and industrial conversion attendant to the demands of a growing population. Just a 1% decrease in harvestable trees between now and 2018 would result in an indirect economic loss of over $236 million on Maryland's GDP and a loss of over 1,600 Maryland jobs.

Identifying areas where the forest products industry is likely to be viable in the long term provides focus for effective management activities, but should also be adaptive so that if future conditions change and the forest shows signs of stress or decline, silvicultural management techniques can be adjusted. Programs and policies should be developed—through financial incentives and cost share programs—that encourage private forest and waterfront or riparian landowners to favor the retention of forests and other native habitats over development and conversion. Additional attention should address streamlining and modernizing the processing, manufacturing, reduction or beneficial use of waste and by-products (to create heat and power), and distribution aspects of this important resource-based industry.

The intent of potential industry directives should be to enhance a broad-based understanding of the measurable environmental and economic benefits attendant to a healthy forest system and the stewardship practices of private landowner and industry alike, which would serve to help Maryland meet its commitment under the Chesapeake 2000 Agreement and the 2007 Forest Conservation Initiative. Any initiatives should take into account impacts from climate change, and may include:

- Integration and streamlining of land conservation (acquisition and easement) programs within DNR and across state agencies and local governments to better prioritize the conservation and restoration of forest and stream or coastal buffer habitats, and meet the goals established by the Maryland Wildlife Diversity Conservation Plan;
- Adopting management plans that incorporate 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, with expansion in accompanying industries (e.g., Fuels for Schools program), expanded use of

genetically preferred species, and salt tolerant species within projected SLR impacted areas, modified biomass removal practices;

- An initiative that directs the use of local wood for construction, furniture or other value-added wood products to enhance local economies, while reducing carbon emissions by lowering transportation distances and sequestering carbon in those products; and
- Forest stewardship plans—on both public and private forestlands—that will, among other things, foster forest landowners to better manage their land for wildlife habitat enhancement, sustainable timber production, and the protection of soil and water quality, wetlands and streams by re-developing forested riparian buffers with salt tolerant species.

Agriculture Industries

The total market value of agricultural goods produced in Maryland was estimated at $1.3 billion in 2006. Within the state there are approximately 12,000 farms, totaling over 2 million acres of farmland. A number of these operations, both agriculture and livestock combined, lie in low elevation areas, and are subject to flooding and inundation as a result of SLR. Long-range management plans should discourage further establishment of operations within these areas and, where feasible, be relocated or protected to minimize impacts. Additional considerations should be made to protect or move groundwater wells and waste storage structures associated with existing operations in vulnerable areas.

Potential industry directives could include: identifying and utilizing new non-conventional agriculture crops which are salt tolerant; expansion of nurseries specializing in native wetland plants for use in nonstructural erosion-control projects, or "living shorelines"; processing the by-products of farm practices (chicken litter, methane, slash, switchgrass, cornstalks, and other agricultural by-products and feedstocks) for renewable energy and transportation fuels; and state and local level programs that promote the sustainable production and consumption of locally produced agricultural goods, or so-called "Buy-Local" initiatives.

Tourism Industry

More than 28 million people visited (traveled more than 50 miles) Maryland in 2006 and generated more than $11.72 billion in spending, according to the Maryland Tourism Development Board. Roughly 62% of the state's tourist activity occurs in the coastal counties, beaches and waterfront destinations. Of particular interest, resource-based recreational activities contribute significantly to Maryland's economy. Recreational saltwater fishing generated nearly $308 million, and wildlife watching activities generated over $30 million that same year, according to the US FWS. One of Maryland's (and Virginia's) most popular national parks, Assateague Island National Seashore, attracted 1.9 million visitors in 2006, which spent nearly $140 million and supported over 2,600 jobs (in Maryland and Virginia). This island is particularly vulnerable to SLR, as it is a long, narrow, low barrier island. This economic base is contingent on the continued availability and accessibility to the natural resources that define Maryland and the Chesapeake Bay region.

Marine Trade and Port Activities

The recreational marine trades industry in Maryland contributes $2.3 billion per year to the economy, employs more than 28,000, and serves some 220,000 boats registered in Maryland, plus boats visiting from other states. This industry is comprised of boatyards, marinas, and commercial marine service facilities, including docking, service, and market facilities for the catch. Many of the recreational and commercial facilities are located on the waterfront within a few feet of the current sea level. These water dependent businesses are especially vulnerable to the impact of SLR. Depending on the elevation of adjacent upland land, some will ultimately need to relocate; others will be able to defend against SLR by raising the elevation of their properties.

Port activities account for a significant portion of Maryland's economy and employment. The Port of Baltimore produces $1.98 billion in annual economic benefits and provides for 127,000 maritime related jobs. According to the report "*Economic Impacts Generated by the Port of Baltimore in 2005* (August 22, 2006)," the Port of Baltimore was responsible for $1.1 billion in local purchases by businesses directly dependent on port activity; activities of the Port generated state, county and municipal taxes of $278 million; and the U.S. Customs and Border Protection (US CBP) collected $507 million in 2005. These facilities require appropriate water depth for port maintenance, and SLR impacts will need to be addressed through strategic planning efforts.

Coastal Management and Restoration Industries

Managing shoreline erosion, either through living shorelines, or other stabilization methods, will continue to grow as an emerging industry in Maryland's coastal counties. In addition, other industries related to coastal ecosystem and infrastructure management, whether it is wetland or forest restoration, retrofitting of coastal infrastructure or water management, will continue to grow and prosper. Many new economic opportunities will develop. Efforts should be focused to support these emerging industries and developing guidance on standardized practices and fostering innovations represents opportunities in restoration and coastal management economies that should be harnessed (Cross-cutting with Sustainable Shorelines and Buffer Area Management Practices, Economic Development Initiative).

Option Design

Targets:

The resource-based industries discussed above are vulnerable to a broad spectrum of climate change impacts beyond SLR and coastal hazards. Due to limitations of state staffing and financial resources, a concurrent evaluation of all resource based industries does not appear to be feasible. The Adaptation and Response Workgroup staff will consult with the Scientific and Technical Working Group of the MCCC to determine a protocol and priorities for evaluating specific resource-based industries and their relationship to SLR.

Phase 1: Research and Data Collection

Teams with expertise within the resource-based industry should convene to evaluate key vulnerabilities and potential economic impacts from climate change. The team will conduct an assessment intended to provide guidance to decision and policy makers. Research should address, but not be limited to, these key areas:

- Identification of geographic areas vulnerable to SLR and coastal hazards that currently support resource industries;

- Assessing the importance of the system(s) at risk, in terms of ecosystem goods and services, and the direct economic impacts on the state as a result of no action (e.g., loss of jobs, loss of revenue from residents and visitors of the state, loss of ecosystem services), and should consider the magnitude, timing, persistence, and likelihood of potential economic impacts; and
- Identification of prospective adaptation mechanisms with associated cost and benefit analyses.

Phase 2: Systematic and Strategic Planning

Subsequent to the economic studies, overarching management and planning guides for the industry should be developed using a crosscutting, systematic and strategic approach. Areas of consideration include:

- Developing a framework for making abandon, modify, move, or protect decisions to address long-term strategic planning and potential solutions for at risk facilities and operations;
- Identifying potential areas for streamlining costs via processing and manufacturing, transportation and distribution, and waste reduction and utilization;
- Identifying potential supplement or replacement industries to promote alternative businesses or practices, which can supplement or replace traditional means;
- Inclusion of a mechanism to monitor or track leading economic indicators of change within each sector (i.e., geographic ranges, migratory patterns, disease outbreaks, invasive species) of certain species (e.g., plants, birds, mammals, insects) known to be hypersensitive to early climate change impacts and have significance to the economics of a particular industry; and
- Identifying specific targets and timelines for each sector or industry.

Phase 3: Implementation

The implementation of the management and planning programs could occur via programmatic modifications, executive order, or legislative action. Strategies could include:

- Mitigation of regulatory and programmatic burdens to facilitate sustainable management of natural resources in the face of climate change;
- Development of guidance and training programs for professional and public development; and
- Identification of opportunities within existing programs, or development of new financial assistance programs, that focus on proactive or prevention management rather than reactive treatment (e.g., non-conventional crop use and tree species, protection of groundwater wells and waste storage structures of poultry and livestock operations).

Timing: Phase 1 would begin following the release of the final report from the MCCC to the Governor, and no later than 2009. Appropriate and key partners will be identified to participate in the research and assessment team for the established priority industry. Phase 2 would initiate immediately following the completion of the assessment. Implementing proposed strategies and programs, Phase 3, would occur in different stages. Other industries should comply as seen fit.

An intensive public-relations effort should accompany the implementation phase. This should be directed at the citizens of Maryland particularly located in future SLR impacted areas, but span across the various resource-based sectors. This program should run indefinitely (continuous), and be evaluated every 5 years for effectiveness.

Parties Involved: DNR, MDA, MDE, numerous fisheries, forestry, and agricultural organizations, and business interests.

Other: Various levels of local government, CPB, NRCS, USFS, the Partnership of Sustainable Forestry, private landowners, public landowners, private sawmills, landscaping industry, nursery industry, Maryland Cooperative Extension (MCE) and Master Gardeners, 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-yourself products, architects and designers), applicable trade associations, Leadership in Energy and Environmental Design Green Building Rating System™ (LEED™) certification entities, and others.

Implementation Mechanisms

There are many existing programs (e.g., agricultural assistance, economic development grants) and policies in place that will support the implementation of this option. Overall implementation would include such elements as land acquisition, conservation easements, purchase and transfer of development rights, tax credits and structures, and zoning. The toolbox would also include refining land use planning policies and funding programs to allow users of these tools—governments, non-governmental organizations and private citizens. Additional opportunities include the utilization of new Farm Bill program funding to promote alternative crops. State and local regulations may be needed through existing zoning programs to regulate new poultry and livestock operations in at risk areas. The MDE may need to investigate if existing regulations are in effect for the installation of well protection devices to prevent saltwater contamination of groundwater sources.

Specific incentives include the following:

- Provide credit through LEED for sustainable wood products grown and harvested locally;
- Increase incentives through programs (such as Fuels for Schools, tax-forgiveness);
- Establish incentives for utilizing renewable heating fuels (such as tax credits similar to those afforded electric producers in the Maryland Clean Energy Act); and
- Support all activities through an extensive outreach and education effort.

It should be noted this recommendation has multiple areas of crosscutting implementation mechanisms for a recommendation being proposed by the Future Built Environment and Infrastructure Technical Working Group (FBEI)—"Economic Development Initiative."

Related Policies/Programs in Place

Fisheries Programs

The Task Force on Fisheries Management, created by Chapter 217 of the Acts of 2007, is charged with overseeing a full review of current fishery management processes and developing recommendations for methods to improve, modernize, and streamline fishery management. The Task Force will look in depth at a range of fisheries conservation challenges, management issues, and a variety of science concerns, including stock assessment capabilities and limitations, ecosystem based interactions, and socioeconomic considerations associated with Maryland's fisheries.

Farming and Forestry Assistance Programs

DNR and MDA, the U.S. Department of Agriculture (USDA), academic resources, such as those made available through the UM system, and local forestry and farming boards offer a wide range of technical, financial and research assistance and training programs to members of the state's rural resource-based industries. Adaptation guidance and assistance can be developed and delivered through these existing programs, so long as financial resources are made available to them to effect responsive outreach efforts.

Feasibility Issues

Due to limitations of state staffing and financial resources, it does not seem feasible to conduct concurrent evaluations for all resource-based industries. A protocol should be established to prioritize the timing of such evaluations, and be based on MCCC findings and state agency priorities. Implementing any policies, initiatives, or programs that result from said evaluations would require further appropriation of staff and funding.

Status of Group Approval

Unanimous

Barriers to Consensus

None.

Acronyms and Abbreviations

CBP	Chesapeake Bay Program
CCI	Comprehensive Coastal Inventory
CREP	Conservation Reserve Enhancement Program
CSI	Comprehensive Shoreline Inventory
DNR	[Maryland] Department of Natural Resources
EVA	Erosion Vulnerability Assessment
GIS	geographical information systems
LEED	Leadership in Energy and Environmental Design
LSSI	Living Shorelines Stewardship Initiative
MDA	Maryland Department of Agriculture
MDE	Maryland Department of the Environment
MDP	Maryland Department of Planning
NGO	non-governmental organization
NOAA	National Oceanic and Atmospheric Administration
NRCS	Natural Resources Conservation Service
SAV	submerged aquatic vegetation
SEC	shore erosion control
SLAMM	Sea Level Affecting Marshes Model
SLR	sea level rise
SSEA	Strategic Shore Erosion Assessment
UMD	University of Maryland
US EPA	United States Environmental Protection Agency
USFS	United States Forest Service
USFWS	United States Fish and Wildlife Service
VIMS	Virginia Institute of Marine Science
WRP	Wetlands Restoration Program

Maryland Climate Action Plan

Appendix F

Stakeholder Letters

Severstal Sparrows Point

Redland Brick

Comments for ES-3 Cap-and-Trade

1. *"The MWG supports continued active involvement in RGGI and encourages consideration of the expansion of RGGI to sectors beyond the power sector if the federal government fails to enact a credible national cap and trade program in 2009. For the purpose of this recommendation a credible national cap and trade program must require at least a 20% reduction from current emission levels for covered sectors by 2020."*

National cap and trade programs must be given precedence to achieve competitive balance for manufacturers in Maryland. As currently stated, this draft policy option supports additional cap and trade requirements that would be imposed in Maryland above and beyond a national program. Effects of this policy will encourage manufacturers to leave the state and result in loss of manufacturing employment.

2. *"Maryland should advocate for expansion of RGGI to as many sources as practical, including major industrial emitters, the transportation sector, and the buildings sector (particularly state and university new buildings)."*

Expansion of RGGI cap and trade programs to other sources that include major industrial emitters must be combined with the development of technologies that could be put in place to achieve reductions. Without the availability of reduction technologies, the effect of this expansion of RGGI will reduce manufacturing production and competitiveness of manufacturers in Maryland.

3. *"Major industrial emissions should be regulated at the point of emissions, ..."*

Regulation that is restricted to the point of emissions does not afford manufacturers the ability to achieve reductions in GHG emissions that would be achieved by energy efficiency and renewable energy programs. These types of programs would reduce purchased energy requirements or indirect emissions only. Manufacturers that complete capital expenditures to reduce energy consumption in support of climate action initiatives must have a reporting mechanism.

4. *"Emissions projections data come from: 1) CCS inventory..."*

The current CCS inventory does not accurately reflect GHG emissions from manufacturing and industries in Maryland. Cap and trade programs developed from this inventory will not provide an acceptable cap and reduction projections for economically successful manufacturing in Maryland.

ES-3 Cap-and-Trade

Policy Description

Use of competitive forces within a cap and trade regime will provide the incentives for economic investment and efficient technological innovations necessary to achieve the desired environmental improvements. Under a GHG emissions trading program, the regulatory agency sets a maximum limit or *cap* on the total amount of emissions (in tons) of greenhouse gases (e.g., CO_2 or CO_2 equivalent for other covered gasses). The *cap* limits emissions from all covered facilities in a specific sector (e.g., electric generation). The program generally requires that the *cap* will be reduced over a period of years to achieve emission reduction targets.

The regulatory agency implements an emissions trading program by creating and distributing a specific number of *allowances* for use by regulated entities. An *allowance* represents an authorization to emit a specific amount of a pollutant (generally measured in tons) during a particular *compliance period*. The total amount of *allowances* cannot exceed the *cap*, thereby limiting total emissions.

At the end of each compliance period, each regulated entity must demonstrate that it possessed sufficient allowances to cover all emissions of the capped pollutant. If an entity releases emissions (for a particular compliance period) in excess of the allowances it holds, it can meet the program requirements by buying additional allowances from entities that have excess allowances due to reduced emissions. This exchange of allowances is called a *trade*. In effect, the seller of the allowances is rewarded for reducing its pollution below its number of allowances and the buyer of the allowances must pay a premium for releasing emissions in excess of its allocated level.

Through trading, participants with lower costs of compliance can choose to over-comply and sell their additional reductions to participants for whom compliance costs are higher. In this fashion, overall costs of compliance are lower than they would otherwise be. Programs that sell or auction allowances, as opposed to distributing them freely, rely less upon trading since the entity that over-complies with expected emissions reductions will avoid the cost of purchasing the allowances in the first place. The entity that requires additional allowances can purchase them at auction or from a secondary market. The compliance obligation for the cap-and-trade program can be imposed "upstream" (at the fuel extraction or import level) or "downstream" at points of fuel consumption or points of emissions.

One key policy issue in designing a cap-and-trade program relates to the treatment of energy efficiency and renewable energy (EERE). Unless a cap-and-trade program is well-designed, it will not assure the maximum achievable GHG reductions from renewable energy and energy efficiency projects.

There are several policy options available to assure that EERE development results in overall CO2 emission reductions under a GHG emissions trading program. For example, Maryland could adopt a key optional section of the model rule issued by the Regional Greenhouse Gas

Initiative (RGGI). This optional section authorizes States to retire allowances on behalf of voluntary purchases of renewable energy. However, if EERE programs and projects are not accounted for under the cap (through the retirement of allowances or in setting the level of the cap) in any future GHG emissions trading program that might be established in Maryland, then they will not affect the overall level of CO_2 emissions.

Among the other important considerations in designing a cap and trade program are: The geographic scope, the sources and sectors to which it would apply; the baselines for these sources and sectors; the level and timing of the cap; and what, if any offsets, would be allowed. Other issues to consider include which greenhouse gases are covered; whether there is linkage to other trading programs; banking and borrowing of allowances, and early reduction credit.

Maryland is already a partner in the Regional Greenhouse Gas Initiative, a cap-and-trade program for large electric power plants. As a result, nearly all of the questions regarding the program design and implementation have been resolved through the RGGI process. The MWG supports continued active involvement in RGGI and encourages consideration of the expansion of RGGI to sectors beyond the power sector if the federal government fails to enact a credible national cap and trade program in 2009. For the purpose of this recommendation a credible national program must require at least a 20% reduction from current emission levels for covered sectors by 2020. (1)

Policy Design

- **Goals:** Caps for electric power plants should match the RGGI goals, which are 2005 emissions starting in 2009 through 2014, followed by a 10 percent reduction through 2019. Other sectors could be included if RGGI were to expand by sector. If this were to happen the resulting reductions should contribute to the State goal, which is anticipated to be 25% below 2006 emissions by 2020 and 90% below 2006 emissions by 2050. These caps should be revisited periodically to reflect current scientific understanding of climate change.
- **Timing:** The state should meet the timing requirements set by RGGI for electric power plants, specifically the adoption of Maryland's RGGI Rule in sufficient time to allow a January 1, 2009 program start. Non-RGGI sectors should be studied for potential inclusion in RGGI and pursue complementary policies and measures in order to meet the state goal.
- **Parties Involved:** As a member of RGGI, Maryland must coordinate with the other members on matters involving the electric power sector. The MWG believes that a credible national cap and trade program is preferable to regional efforts like RGGI, and as stated above encourages enactment of such a program by Congress before the end of 2009. However, in the event that this does not happen and the RGGI members seek expansion of the program to include other sectors, Maryland should design its program to blend into the expanded regional effort. Maryland should advocate for expansion of RGGI to as many sources as practical, including major industrial emitters, the transportation sector, and the buildings sector (particularly state and university new buildings). Inclusion of those sectors that are easier to regulate can begin prior to more complicated sectors. (2)
- **Other:** For offsets that are a part of the cap-and-trade system, care should be taken that local jurisdictions can apply for offsets for qualifying programs which they create.

  Linkages to external comparable programs should be explored. The state should strongly advocate links to other regional or national programs of equal strength and effectiveness.

Implementation Mechanisms

There are three key implementation mechanisms. The first concerns the designation of the entity responsible for acquiring and surrendering allowances for emissions, or "point of regulation". In some sectors, such as major industrial emissions, this is simply the in-state entity operating the facility from which the emissions are released.

RGGI has adopted a production-based (smokestack) system for the electrical power sector but is considering modifying this approach to incorporate greater consideration of load-based (consumer) emissions. The Western Climate Initiative states are considering a more load-based approach.

If RGGI were to expand to include additional sectors there will likely be a need to vary the "point of regulation" depending on the sector. There are many pros and cons to each approach which should be comprehensively fleshed out in the program development phase.

The transportation sector offers a challenge because a program requiring the surrender of allowances from the end users of motor fuels would be complex and is generally thought to be unworkable. Therefore, transportation sector emissions should be regulated upstream, focusing on the entity that imports or distributes the petroleum in the state.

Natural gas also should be regulated upstream, again focusing on the entity that imports the natural gas into the state. Major industrial emissions should be regulated at the point of emissions, except to the extent emissions are associated with natural gas and petroleum that has already been regulated upstream. Emissions of certain high global-warming potential gases may also be regulated upstream of their usage (e.g. at the distribution level) if more practical. (3)

Allowances may be distributed by auction or given free-of-charge to covered entities. The State of Maryland has decided to auction 100% of its RGGI allowances. Maryland may want to consider a different allowance distribution approach for new sectors if and when they are added.

The second key implementation mechanism concerns offsets. Offsets are out-of-sector emissions reductions or carbon sequestration projects that are recognized by the program as qualifying for allowance credit. By definition, offsets must be measures that are not required by the program, and they cannot be required by any emissions reduction program in most cases. They provide an incentive for low-cost investments in emissions reductions as an alternative to higher-cost in-sector reductions or allowance purchases. Offsets should be subject to stringent standards to ensure their environmental integrity, and should be limited to ensure that the overwhelming majority of emission reductions come from covered sectors. Any offsets allowed under the program should be real, verifiable, surplus, permanent, and enforceable.

Related Policies/Programs in Place

A Carbon Tax (ES-9) is seen as a complementary policy, applying to sectors not covered by the cap and trade.

Types(s) of GHG Reductions

All 6 statutory GHGs (CO_2, methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride)

Estimated GHG Reductions and Net Costs or Cost Savings

Model scenarios for the Cap and Trade policy are limited to the ten RGGI states and the power sector. Runs were performed assuming two initial allowance allocation strategies: (1) all allowances are freely given to regulated sources and (2) all allowances are auctioned. Due to the nature of some state emission caps and the state allowance budgets in 2020, allowance prices could not be projected to the exact dollar level. Instead, multiple runs were conducted assuming prices ranging from $1 to $7 per tCO2. Given that Maryland has decided to auction all allowances, only those results are presented here. Results from the free distribution model are given in the Annex to this report. In the auction case with a hypothetical allowance price of $7/tCO2, each state would utilize all its mitigation potential with a marginal cost less than $7/tCO2 before purchasing allowances from the auctioneer. As a result, the total emission reductions achieved by the 10 states in this case are 41.50 MMtCO2. Although considerable amounts of un-used mitigation potentials of some states such as MD and MA in the free granting case are associated with cost savings, the total cost savings of mitigation in the auction case (2.53 billion) are even higher than the total mitigation cost savings in the free granting case (1.94 billion). In addition, in the auction case, many states would reduce more emissions than required by the state mitigation target. The reason is that there is a penalty for each unit of CO2 emitted even if it is below the cap—this is the price of an auctioned permit that is required to emit. The additional reductions achieved by these states can, however, be saved for future use.

Comparing the two auction prices of $7 and $1, the amount the states choose to reduce by mitigation options (41.50 MMtCO2 vs. 39.62 MMtCO2, respectively) and the amount to be bought from the auctioneer (134.79 MMtCO2 vs. 136.68 MMtCO2, respectively) differ slightly. The trend is that the higher the auction price, the more the states choose to mitigate on their own and the less they buy from the auctioneer. The big difference of these two cases is the total auction cost. And this difference is primarily due to the difference in the two auction price levels.

At an assumed allowance price of $7 per ton in 2020, regulated sources within Maryland can expect to mitigate 16.66 MMtCO$_2$e at a total cost savings of $604 million. In addition, they will purchase 22.17 million allowances (1 allowance mitigates 1 ton of CO_2) at a total cost of $155 million. The net savings is therefore $449 million. The expected cost savings from mitigation without the cap and trade would be approximately $408 million (assuming Maryland would only comply to the state cap set by RGGI—17.9% reduction of 2020 BAU-- and would not pursue further mitigation even though there are additional cost saving potentials), yielding a net cap and trade program savings to Maryland of $41 million in 2020. This does not include any savings that might be realized through the expenditure or application of auction revenues ($155 million). The cost-effectiveness of the auction-based C&T is computed in two alternative ways. The first way is to compute the cost-effectiveness by dividing the total net cost (mitigation cost plus auction cost) by all the emission reductions undertaken by MD under the C&T. The second way is to divide the total net cost by just the capped level of CO2e reductions. The former yields a cost-effectiveness of -$26.9/tCO2e and the latter yields a cost-effectiveness of -$36.4/tCO2e. Please note the second way of computation would reduce some of the double counting of benefits with other policy options.

At an assumed allowance price of $1 per ton in 2020, regulated sources within Maryland can expect to mitigate 15.7 $MMtCO_2e$ at a total cost savings of $608 million. In addition, they will purchase 23 million allowances (1 allowance mitigates 1 ton of CO_2) at a total cost of $23 million. The net savings is therefore $585 million. Compared with the expected cost savings from mitigation without the cap and trade ($408 million), the net cap and trade program savings to Maryland is $177 million in 2020. Again, this does not include any savings that might be realized through the expenditure or application of auction revenues ($23 million).

The cost associated with the auction of allowances is assumed to be fully passed on to consumers. Under Maryland's deregulated environment, some portion of the cost may in fact be borne by the owners and shareholders of these facilities. Any portion of the allowance cost that is not passed along to consumers would represent additional savings in the cost/ton column.

Finally, no assumption is made concerning indirect impacts through the broader economy of costs or savings resulting from this policy.

Data Sources:

Emission projections data come from: 1) CCS inventory and forecast studies of respective states, or 2) publicly available data from EIA *Annual Energy Outlook 2007* for states lacking detailed bottom up assessments. (4)

Reduction potentials and cost-effectiveness data of mitigation options for the states are used to develop the cost curves. The data sources are:

1) Connecticut Governor's Steering Committee on Climate Change. 2005. *2005 CT Climate Change Action Plan.* http://www.ctclimatechange.com/StateActionPlan.html.

2) Maryland Commission on Climate Change. 2008. *Draft Straw Proposals of Policy Options.* http://www.mdclimatechange.us/GHG_Carbon_Mitigation_WG.cfm.

3) Maine Department of Environmental Protection. 2004. *Final Maine Climate Action Plan 2004.* http://www.maine.gov/dep/air/greenhouse/.

4) Center for Clean Air Policy and New York GHG Task Force. 2003. *Recommendations to Governor Pataki for Reducing New York State Greenhouse Gas Emissions.* http://www.ccap.org/pdf/04-2003_NYGHG_Recommendations.pdf

5) Rhode Island Greenhouse Gas Process. 2002. *Rhode Island Greenhouse Gas Action Plan.* http://righg.raabassociates.org/.

6) Vermont Governor's Commission on Climate Change. 2007. *Final Report and Recommendations of the Governor's Commission on Climate Change.* http://www.anr.state.vt.us/air/Planning/htm/ClimateChange.htm.

There are no direct mitigation options data for MA, NJ, NH, and DE. Marginal cost curves for these four states are developed based on cost curves of RI, NY, CT, and MD, respectively.

Quantification Methods:

In this study, a non-linear programming model of emission allowance trading is used. This model is based on the well established principles of the ability of unrestricted permit trading to achieve a cost-effective allocation of resources in the presence of externalities.[1] The model requires equalization of marginal cost of all trading participants with the equilibrium permit price. This ensures minimization of total net compliance costs for each state and minimization of total abatement costs for the cap-and-trade program as a whole.[2]

The marginal cost curves of the states are developed based on the reduction potential and mitigation cost/saving data of individual options that contribute to the emission reductions from power sector. These options not only include those designed directly for the electricity supply sector (such as promotion of renewable energy utilization, repowering existing plants, generation performance standards, etc.), but also include options in RCI sectors that contribute to the reduction of electricity consumption (e.g., demand-side management, energy efficiency appliances, building codes, etc.). The emission reduction potentials of these options are adjusted by multiplying the percentage of electricity consumption to total energy consumption in the RCI sector. RCI options that relate entirely to reduction of other fossil fuels consumption (such as gas, oil) are not included in the cost curves.

Key Assumptions:

The purpose of the simulations is to illustrate the economic impacts of the RGGI cap and trade program to Maryland under particular design scenarios.

All emissions considered are production-based and are gross emissions (excluding sinks).

The economic modeling conducted in this study helps to analyze the potential GHG reductions and associated cost for Maryland under several scenarios of different design configurations using the following variables: allocation methods (auctioning vs. free granting of permits), hypothetical allowance prices (at the range of $1 to $7 per tCO2).

A full list of assumptions adopted in the simulation model is presented in the Appendix.

Key Uncertainties

Market prices are bound to fluctuate and allowance price spikes and crashes are not uncommon in new programs as the market gains experience. RGGI has incorporated a number of design features to mitigate these tendencies but only actual experience after allowances are offered for sale will prove the point. Emission reductions result when the supply of allowances is less than

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[1] See, for example, T. Tietenberg, 1985. *Emissions Trading: An Exercise in Reforming Pollution Policy,* Washington, DC, Resources for the Future.

[2] See, for example, B. Stevens, and A. Rose, 2002. "A dynamic analysis of the marketable permits approach to global warming policy: A comparison of spatial and temporal flexibility," *Journal of Environmental Economics & Management* 44(1):45–69; A. Rose, T. Peterson, and Z. Zhang, 2006. "Regional Carbon Dioxide Permit Trading in the United States: Coalition Choices for Pennsylvania," *Penn State Environmental Law Review* 14(2):203–229.

the unconstrained level of emissions. The RGGI cap was set several years ago and the precise quantity to force reduced emissions may not be found until the program has operated for one compliance period.

Additional Benefits and Costs

Additional benefits include the apparent effect on regulated entities that the anticipation of the program is already encouraging decisions resulting in reduced emissions, even before the program starts. The successful launch of a regional Cap and Trade program to limit GHG emissions will have an effect on policy makers in non-RGGI states and in Washington, D.C.

Feasibility Issues

Feasibility issues have been exhaustively studied through the RGGI development and design phases and have been resolved to the satisfaction of the ten member states. Some questions remain, especially within the context of expansion of the program to additional sectors. The feasibility of extending the Cap and Trade to stationary sources similar to power plants has been tested in the U.S. ($SO2$, NOx), Europe and elsewhere. Application of the approach to some other sectors remains untested and therefore should continue to be studied carefully before implementation.

Status of Group Approval

(to be completed at a future stage)

Level of Group Support

(to be completed at a future stage)

Barriers to Consensus

(to be completed at a future stage)

Planning
JUN 1 1 2008

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June 9, 2008

Redland BRICK
An ISO 9001:2000 Registered Quality System

Mr. Tad Aburn
Maryland Department of the Environment
1800 Washington Boulevard
Baltimore, MD 21230

Re: Greenhouse Gas and Carbon Footprint Reduction Strategy

Dear Tad:

On behalf of Redland Brick Inc., I would like to thank you for inviting me to the meeting on May 29th. We are quite interested in taking part in any subsequent meetings and will appreciate your invitation.

As you know, we have serious concerns about the potential of any legislation related to Greenhouse Gas and Global Warming. What if the models used by the experts to predict Global Warming are wrong? What happens to all of the companies who were negatively affected by legislation that was passed based on false precepts? How will the state rectify things for employees who lost their jobs as a result of their company going out of business? We do recognize that the issue of Global Warming is in vogue and we respect that so our interest is in finding a way to address it that will allow us to survive and hopefully grow as a business.

The manufacturing process of making brick has been unchanged for thousands of years. Only the technology that we work with has improved. We still must quarry and prepare our material, form the brick, dry them, fire them, package them, and ship them. At the end, firing anything creates CO2 emissions, we cannot change that. And currently, there is no technology available in the world today to control CO2 emissions from a brick kiln. But we are firing our kilns with natural gas, the cleanest burning fuel available, and we have invested heavily in fuel efficient kilns. At our Rocky Ridge Plant we reduced our energy consumption from 1500 BTU to 900 BTU's per thousand brick fired.

As I read through Chapter Four, I was surprised at how many recommendations that are going to be made that are consistent with things we have already done. We are in favor of energy efficiency and recycling. Below I have listed just a few of the positive environmental practices we have adopted. We have done a few things as a result of regulation but most of the environmental practices listed below we have done as a matter of survival. I welcome you to come to our plants and see what we have done first hand.

Our list is as follows:

1. All scrap clay in the manufacturing process is recycled back through the manufacturing process. Scrapped, fired brick are used to make quarry roads, used as check dams to slow stormwater runoff, or are chipped and resold.

2. We reclaim areas where we are finished quarrying, generally small sections at a time and the land reverts to the same use as before mining- this amounts to over 1,000 acres of open space and farming. We fertilize the land for planting with processed sewage sludge. If we go out of business this acreage will become housing developments.
3. We have planted over 30,000 tree seedlings during my employment at Redland Brick. The trees planted earliest are now over 30 feet tall.
4. We have maintained the riparian buffer along all streams and waterways at all locations. Our election to do this even caused our engineers to redesign the location of a new plant we built in Pittsburgh.
5. We have a scrubber on the kiln at one Maryland plant that controls our emissions of hydrogen fluoride and hydrogen chloride and will likely install a scrubber on the other plant in a few years depending on new federal regulations currently in development. The spent reagent in the scrubber is lime and it is recycled. We give it to a local farmer to use as lime on his farm.
6. Scrap metal from worn parts is recycled.
7. We have researched the possibility of using methane from landfills for firing our kilns but it is not feasible at our MD locations at present. We are currently looking at wind power and solar power to offset our consumption of electricity.
8. Our brick molds are washed with self contained systems, preventing sediment from entering the local waterways. The water is recycled. Sediment cleaned from the mold wash tanks is used as a backfill in our quarries prior to reclamation or recycled to manufacture brick.

In addition, the use of our product will help Maryland achieve one of the key goals in this report- energy efficient buildings. Secondly, the purchase of brick from our two MD plants will help MD achieve a second goal of minimizing vehicle emissions with the purchase of local products. We own the only two brick plants in MD.

We believe we can stand tall with our record and should be considered a leading, environmentally conscious business. At the same time we are concerned that the practices we have adopted could be a detriment to us if legislation is adopted. So regarding Chapter Four, we have the following comments, questions, and requests:

1. Where is Chapter One through Three? We might have additional comments after reading these or our opinions may change.
2. We need to see the statistical data in the report that is missing as this information may change our opinions. We still question if MD can meet their goals by focusing on the power plants and transportation alone.
3. We believe the report should focus on setting improvement goals based on industry benchmarking and the availability of technology that promotes energy efficiency. Goals set otherwise can be viewed as a disincentive for those who have already been environmentally conscious.
4. Revise P.34- Tax incentives and low interest loans should be extended to all MD manufacturers (not just the power plants) for R & D projects for reduced energy consumption (particularly wind and solar power as well as alternative but clean burning fuels). In addition, MD should simplify, streamline, and expedite the

permitting process to implement these items when they are proven as a legitimate option. Please consider revising this section.

5. On page 35, a revision is needed. MD manufacturers that provide product in MD for energy efficiency or otherwise meeting these goals should be allowed to reduce any potential cap and trade taxes by the dollar amount of product they supply in MD annually, on a dollar for dollar amount. Please consider making this recommendation.
6. On page 35, (cont.) MD manufacturers as in 5 above should be encouraged to grow their businesses via state grants and low interest loans, in recognition of the service they are providing the state i.e. meeting the goals for energy efficient buildings. Note: I can see no mention of business growth anywhere in this report. Please consider a means to address business growth particularly for the manufacturing sector.
7. References to ethanol should be removed from this report. Ethanol has proven to burn with greater emissions than petroleum products, uses more energy to produce than gas and the use of corn in ethanol production has contributed to increased food costs. Environmentalists have accepted this fact and this report should as well.
8. On page 47, under RCI-3, the revolving loans should apply to structural efficiency upgrades as well as appliances as we have been developing a product as a retrofit that may provide improved energy efficiency.
9. Low interest loans should apply to new home construction providing that home construction will be energy efficient.

Please give consideration to the changes I have suggested. I am interested in knowing if you will make these changes and would appreciate your response.

Sincerely,

Barry Miller

Barry Miller

cc. Joseph L. Miles, President/CEO