TECHNICAL SUPPORT DOCUMENT

FOR

PROPOSED COMAR 26.09

CO_2 Budget Trading Program

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I. INTRODUCTION

Primary Purpose of the Regulations

The Maryland Carbon Dioxide (CO_2) Budget Trading Program regulations (the "MD CO_2 Budget Trading Program," or, "the regulations") establish a program to reduce emissions of greenhouse gases, particularly CO_2 from burning fossil fuels to generate electricity. The regulations also directly fund energy efficiency and cleaner energy programs that will lower greenhouse gas emissions.

The Maryland Healthy Air Act of 2006, responding to scientific evidence that CO_2 and other greenhouse gas (GHG) emissions are causing climate change, required that Maryland join the Regional Greenhouse Gas Initiative (RGGI). In 2007, the Maryland Department of the Environment (MDE), in collaboration with the Maryland Public Service Commission (PSC), Department of Natural Resources (DNR), and Maryland Energy Administration (MEA), adapted the RGGI Model Rule to Maryland regulations. The MD CO_2 Budget Trading Program has resulted. In reducing greenhouse gas emissions in Maryland, it serves as a first step toward mitigating the impacts of climate change in the state.

Background

The burning of fossil fuels to generate electricity is a major contributor to the warming of the earth's climate. Fossil fuel burning generators emit large amounts of CO_2, the principal greenhouse gas. The national electricity generation sector accounts for 33% of greenhouse gas emissions, the highest proportion of United States' greenhouse gas emissions.[1] The electricity generation sector accounts for approximately 39% of total CO_2 emissions in Maryland.[2]

Given the significant contribution of the electric generation sector to climate change, the ten states that are signatories to the RGGI Memorandum of Understanding (MOU) decided to propose, as a first step, implementation of a CO_2 constraint on fossil fuel-fired electricity generation and the development of a cap-and-trade program for the trading of CO_2 emissions allowances, a limited authorization to emit CO_2. As of November 2007, the following ten states were members of RGGI: Connecticut, Delaware, Maine,

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[1] This is based on a comparison of seven major economic sectors. Transportation accounted for the second highest proportion, 28%. See United States Environmental Protection Agency (EPA), U.S. Greenhouse Gas Inventory Reports, Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2005 (April 2007), USEPA #430-R-07-002, Executive Summary, http://www.epa.gov/climatechange/emissions/downloads06/07ES.pdf or http://www.epa.gov/climatechange/emissions/usinventoryreport.html, accessed 12/14/07.

[2] Maryland Department of Natural Resources, Power Plant Research Program (PPRP), *Electricity in Maryland Fact Book*, August 2006, page 15, http://esm.versar.com/pprp/factbook/Fact%20bk%2006%20std.pdf, accessed 12/10/07.

Maryland, Massachusetts, New Hampshire, New Jersey, New York, Rhode Island, and Vermont.

Context of Regulations within Regional Process

RGGI is an ongoing effort, begun in September 2002, to reduce CO_2 emissions in the electricity generation sector. The RGGI cap-and-trade program aims to initially stabilize and then reduce CO_2 emissions from large fossil fuel-fired electricity generating units in the region. RGGI has benefited from the combined expertise of environmental and energy professionals in the government, and private and nonprofit sectors.

To begin, the RGGI program sets a cap of 188.1 million tons of CO_2 emissions for the ten-state RGGI region, based in large part on emissions from affected sources.[3] States are given allocations from the RGGI cap based on their emissions. Then, between 2015 and 2018, the RGGI cap is reduced by 10%, and in the process, each state will receive 2.5% fewer CO_2 allowances annually relative to their initial allocation.

The regional cap for RGGI and Maryland's allocations are detailed below.

Year	Regional Annual CO_2 Cap	Maryland's Annual Allowances[4]
2009-2014	188,076,976	37,504,000
2015	183,375,052	36,566,400
2016	178,673,127	35,628,800
2017	173,971,203	34,691,200
2018 and beyond	169,269,278	33,753,600

RGGI's phased approach to reducing emissions, with initially modest emissions reductions, is intended to provide market signals and regulatory certainty so that electricity generators begin planning for, and investing in, lower-carbon alternatives throughout the region. It is also designed to avoid creating dramatic wholesale electricity price impacts and related retail electricity rate impacts.

Reducing Global CO_2 Emissions

According to the Intergovernmental Panel on Climate Change (IPCC), the industrialized countries must reduce their greenhouse emissions to well below 1990 levels if global atmospheric concentrations of CO_2 are to be stabilized at acceptable levels. In concrete terms, global greenhouse gas emissions must be stabilized at 450 parts per million (ppm) CO_2 equivalent (CO_2-eq). Based on IPCC analyses, this would require that greenhouse

[3] The initial regional cap of 188.1 million tons of CO_2 is approximately 4% above average regional emissions during the period 2000-2002. See Appendix I of this document for further information on 2000-2002 emissions in Maryland.
[4] One allowance is equal to emission of one ton of CO_2.

gas emissions are reduced 25-40% below 1990 levels by 2020 and 80-95% below 1990 levels by 2050. Failure to do so could push annual global mean surface temperature past pre-industrial levels by more than 2.0 - 2.4 degrees Celsius (3.6 - 4.3 degrees Fahrenheit), considered the risk threshold for triggering the most catastrophic climate scenarios.[5]

Some debate continues among IPCC contributors about whether the world has already exceeded this threshold. Even at early stabilization levels of 450 ppm CO_2-eq, average temperatures are projected to increase between 0.6°C and 4.0°C (1.1°F - 7.2°F) in this century. The larger the temperature change, the greater the risks to the environment and human health.[6]

Meeting Maryland Greenhouse Gas Reduction Goals

The MD CO_2 Budget Trading Program is a first step toward mitigating some of the environmental and health impacts of climate change in Maryland. Climate change poses a threat to Maryland's air quality, surface and subsurface drinking water supplies, marine and freshwater fisheries, salt and freshwater wetlands, river and stream impoundment infrastructure, and forest species and wildlife habitats.[7] By reducing CO_2 emissions from power generators, Maryland moves closer to the goal set by the Maryland Climate Change Commission[8] to substantially reduce emissions by the middle of the century and mitigate some of the impacts of climate change in the state.

The Maryland Climate Change Commission, in its January 14, 2008 *Interim Report to the Governor and the Maryland General Assembly: Climate Action Plan*, recommends the following overall goals for greenhouse gas reductions in the State:

- By 2012: 10% below Maryland's 2006 GHG emission levels (using a consumption-based approach)
- By 2015: 15% below 2006 levels
- By 2020: 25% below 2006 levels
- By 2050: 90% below 2006 levels

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[5] Intergovernmental Panel on Climate Change (IPCC), Fourth Assessment Report, Working Group III Report, "Mitigation of Climate Change," Chapter 13, "Policies, Instruments and Co-operative Arrangements," page 776, Box 13.7: "The range of difference between emissions in 1990 and emission allowances in 2020/2050 for various GHG concentration levels for Annex I and non-Annex I countries as a group," http://arch.rivm.nl/env/int/ipcc/pages_media/FAR4docs/final_pdfs_ar4/Chapter13.pdf, accessed January 18, 2008.

[6] Summary for Policymakers of the Synthesis Report of the IPCC Fourth Assessment Report, Nov. 2007.

[7] Intergovernmental Panel on Climate Change, Fourth Assessment Report, *Climate Change 2007: Synthesis Report*, Summary for Policymakers, http://www.ipcc.ch/pdf/assessment-report/ar4/syr/ar4_syr_spm.pdf, accessed 12/14/07.

[8] See http://www.mdclimatechange.us.

II. OVERVIEW OF THE REGULATIONS

Summary of Requirements of the Regulations

The MD CO_2 Budget Trading Program affects coal, oil, and gas-fired electric generating units ("sources") with a capacity of at least 25 megawatts. The Regional Greenhouse Gas Initiative (RGGI) MOU requires each member state to auction at least 25% of its annual CO_2 allowances to create a fund to support energy efficiency projects, and to either auction or allocate the remainder of its allowances. Sources will need to purchase and/or be allocated an allowance for each ton of CO_2 they emit annually.

Maryland is proposing to auction 100% of the CO_2 allowances annually allocated to its Consumer Energy Efficiency Account,[9] with the proceeds to go into Maryland Department of the Environment's ("the Department") Clean Air Fund or any other fund authorized by the legislature. Auction procedures are being drafted in Maryland auction regulations.

While the MD CO_2 Budget Trading Program closely follows the RGGI Model Rule, the content has undergone some reorganization to assist in comprehension. The regulations are divided into three chapters under a new subtitle in the Code of Maryland Regulations, COMAR 26.09. Below is a summary of the requirements of the regulations.

Chapter 1: General Administrative Provisions

I. **Definitions** (See COMAR 26.09.01.02)

II. **Incorporation By Reference** (See COMAR 26.09.01.03)

III. **Compliance and General Accounts** (See COMAR 26.09.01.04-.05)

A. **Allowance Accounts**. Each source must designate only one Account Representative and only one Alternative Representative.

B. **Administration of Allowance Accounts**. The Department will establish "compliance accounts" for each CO_2 budget source as long as the source provides required documentation concerning designation of account representatives. The Department will establish "general accounts" for individuals upon request.

C. **Administer Emissions and Allowance Tracking**. The CO_2 authorized account representative for a compliance account or a general account can delegate authority to

[9] Of the allowances that Maryland is allocated annually, 14.7% are set aside, including 0.9% for renewables, 4.5% for long-term contracts, and 9.2% for industrial sources. One hundred percent of the remaining allowances will be auctioned. In addition, unused allowances from the long-term contract and industrial source accounts will be auctioned.

make electronic submissions of information to the Department. This authority can be delegated to one or more individuals.

D. **Retirement of Allowances**. A CO_2 authorized account representative of a general account can retire allowances from an account by requesting a transfer to the Department's CO_2 allowance retirement account. Retiring allowances effectively reduces the number of allowances available for compliance purposes.

IV. **CO_2 Allowance Transfers** (See COMAR 26.09.01.06):

CO_2 authorized account representatives are required to submit information to the Department to request a transfer of allowances to or from their accounts. The Department will record the transfer and notify the account representatives of the transfer.

Chapter 2: Applicability, Determining Compliance and Allowance Distribution

I. **Applicability**.

A. Any fossil fuel-fired unit serving an electric generator with a nameplate capacity of 25 megawatts and greater is subject to the MD CO_2 Budget Trading Program. (See COMAR 26.09.02.02, and the definitions at 26.09.01.02B(32) and 26.09.01.02B(59))

B. The Department will evaluate the MD CO_2 Budget Trading Program by September 1, 2010, considering, for example, the allocation of allowances for auction. The Department will revise the regulations as appropriate.

II. **Distribution of Allowances**

A. **Distribution of CO_2 Allowances** (See COMAR 26.09.02.03A-C)

1. The MD CO_2 Budget Trading Program allowances for 2009-2018 are established (see "Context of Regulations within Regional Process," above).

2. The following set-aside accounts are established:

a. Limited Industrial Exemption (3,465,101 allowances)
b. Long-Term Contract (1,698,191 allowances)
c. Voluntary Renewable (350,000 allowances)
d. Consumer Energy Efficiency (all remaining allowances)

B. **Allowances Available for Auction and Purchase:** Maryland will auction up to 100% of its annual allowances allocated to the Consumer Energy Efficiency Account. Under a trigger provision applicable from 2009-2011, if the auction closing price reaches $7, up to 50% of a year's allowances will be reserved for purchase by the

sources at $7 per allowance. This allows units an option to purchase allowances directly from the Department. Allowances not purchased by the end of the year will be auctioned in the next year. (See COMAR 26.09.02.03C-D)

C. **Demonstrating Compliance**. Each source must cover its emissions with the CO_2 allowances in its compliance account at the CO_2 allowance transfer deadline. This falls on March 1 after the control period ends. (See COMAR 26.09.02.03E and the definition at COMAR 26.09.01.02B(28))

1. The **control period** is a 3-year period unless extended to four years by a "stage two trigger event," which occurs if the average allowance price exceeds $10 (2005 dollars adjusted based on the Consumer Price Index) on a 12-month rolling average basis. The first 3-year compliance period begins January 1, 2009. (See definition at COMAR 26.09.01.02B(49))

2. **Eligible Biomass.** CO_2 emissions associated with the burning of eligible biomass are deducted from a source's total CO_2 emissions. (See COMAR 26.09.01.03E(2) and definition at COMAR 26.09.01.02B(52))

3. **Excess Emissions.** If at the end of a control period, a source has failed to cover all of its emissions with allowances, the Department can deduct up to three times the deficit from the source's future allocations. This is in addition to any state-specific penalties that may apply to the violation. (See COMAR 26.09.02.03E(4))

III. **Permits**. Each source must apply for and have a CO_2 budget permit from the Department. (See COMAR 26.09.02.04) The CO_2 budget permit would include the specific regulatory requirements for monitoring, reporting, and compliance with the MD CO_2 Budget Trading Program and would be part of the source's Title V Operating Permit.

IV. **Compliance Certification and Early Reductions** (See COMAR 26.09.02.05)

A. **Compliance Certification**. Each authorized account representative must file a compliance certification report by the March 1 following the end of each compliance period ("control period"). (See COMAR 26.09.02.05A-B)

B. **Early Reduction Allowances.** Early reduction allowances will be issued for qualifying actions taken by a source to reduce their CO_2 emissions prior to the start of the program, in 2006, 2007, and 2008. The source must demonstrate a reduction in the average CO_2 emissions rate resulting from electric energy output and thermal energy output for all the CO_2 budget units at the source. Like offset allowances, these allowances would be awarded in addition to Maryland's CO_2 budget. (See COMAR 26.09.02.05C)

C. **Limited Industrial Exemption Set-Aside Account**. Maryland is including this optional exemption, whereby if a unit supplies less than or equal to 10% of its electrical output to the grid, it can apply to be exempted from the program. Requirements to qualify for this exemption include agreement to a permit condition that limits the CO_2 budget unit's output to the electric grid to less than 10% per year and requires a climate action plan to address reduction of CO_2 emissions. (See COMAR 26.09.02.06)

D. **Long Term Contract Set-Aside Account**. This provision provides allocations to CO_2 budget sources that can demonstrate, to the Department's satisfaction, that their long-term contract has existed since January 1, 2001 and that purchasing of allowances equal to the source's CO_2 emissions will affect the financial viability of the plant or its direct or indirect corporate owners. (See COMAR 26.09.02.07)

E. **Voluntary Renewable Set-Aside Account**. The Department will administer this account to encourage renewable energy projects or to retire allowances in exchange for voluntary renewable energy purchases by ratepayers.

V. **Emission Monitoring, Reporting and Recordkeeping** (See COMAR 26.09.02.09-.10)

Each source must monitor its CO_2 emissions in a manner consistent with existing practices under federal acid rain regulations (see (40 CFR Part 75) for monitoring emissions of oxides of nitrogen (NO_x) and oxides of sulfur (SO_x). Each source must collect, record, quality-assure and report data necessary to quantify CO_2 mass emissions and file quarterly emissions reports and annual output reports. Sources have the option to submit to the Department a petition for an alternative monitoring plan.

MD CO_2 Budget Trading Program sources that are also subject to the federal Acid Rain Program are already required under the Acid Rain program to monitor, record and report CO_2 mass emissions annually. Sources that are not Acid Rain sources are nonetheless subject to the Clean Air Interstate Rule (CAIR), which requires sources to report mass emissions of NO_x on an annual basis. The CAIR equipment for monitoring NO_X emissions on an annual basis is also capable of monitoring for CO_2 mass emissions and would need only additional programming with the formulas for CO_2 in order to quantify CO_2 mass emissions.

Chapter 3: Offset Projects

I. **General Requirements**. The MD CO_2 Budget Trading Program provides for the award of CO_2 offset allowances to sponsors of projects that fall in one of five categories (see COMAR 26.09.03.02):

A. Landfill methane gas (CH_4) capture and combustion;

B. Sulfur hexafluoride (SF_6) capture and recycling, storage, or destruction;

C. Sequestration of carbon through afforestation, the transition of land from a non-forested to a forested state;

D. Reduction or avoidance of CO_2 emissions through end-use energy efficiency projects in buildings that combust natural gas, propane, or heating oil for their use; and

E. Capture and destruction of CH_4 from farming operations.

An initial list of project categories was selected with consideration of the following: expected offset supply within the borders of RGGI states; the existence or the relative ease of developing standards; and the low likelihood of mandatory greenhouse gas regulations for that sector. The five project types listed above have measurement and verification protocols and certification processes that will be consistent across the RGGI states.

Maryland supports the future addition of two new offset categories: (1) carbon sequestration through salt marsh restoration and conservation, and (2) carbon sequestration through the creation or enhancement of urban forests. Appendices II and III provide background information on these offset categories. As of the writing of this technical support document, these categories have not been approved by the ten states that are signatories to the RGGI MOU (the "RGGI States"). Maryland continues to work with the RGGI States to add these offset categories.

II. **Limit on Use of Offsets for Compliance**. A source may cover up to 3.3 % of its CO_2 emissions with CO_2 offset allowances unless (see COMAR 26.09.02.03E):

A. The 12-month rolling average spot price for allowances is $7 or more (2005 dollars adjusted based on the Consumer Price Index), in which case 5.0 % of a source's emissions can be covered with offsets; or

B. The 12-month rolling average spot price for allowances exceeds $10 for two consecutive 12-month periods (2005 dollars adjusted based on the Consumer Price Index), in which case 10.0 % of a source's emissions can be covered with offsets.

III. OVERVIEW OF CONCEPTS BEHIND THE REGULATIONS

Auction and Allocation

The inclusion of a trigger provision in the regulations (see COMAR 26.09.02.03C), under which sources can purchase allowances at $7 per allowance if the auction closing price reaches $7, assures generators that allowances for compliance will be available despite uncertainty in the new CO_2 market. The provision will apply to the first control period, a time period suggested by the University of Maryland Center for Integrative Environmental Research (CIER) and its contractors as ample time for the new CO_2 market to stabilize.

Maryland considered the following in its decision to auction 100% of the allowances allocated to its Consumer Energy Efficiency Account: Market research indicates that auctioning a greater percentage of allowances will produce a higher benefit in terms of CO_2 reductions by providing a larger store of money for energy efficiency programs.

Maryland added the trigger provision to the regulations in consideration of the following:

> (1) Throughout the stakeholder comment process, Maryland generators expressed concerns at not being able to acquire adequate allowances at a reasonable cost due to speculation in the new CO_2 market; and
>
> (2) Maryland has more coal generators than most RGGI states.

Banking

Banking provides sources with the ability to carry over unused allowances from a current compliance period into future compliance periods with no restrictions. This allows sources to ensure that they have enough allowances to use in future years to cover higher than expected emissions. Overall, banking should result in lower allowance prices and greater allowance price stability. Banking is permitted under the Federal Acid Rain Program, the NO_x State Implementation Plan (SIP) Call, and the Clean Air Interstate Rule (CAIR).

IV. COMPARISON OF THE REGULATIONS TO FEDERAL STANDARDS

No federal regulation currently exists for the control of CO_2 emissions from the burning of fossil fuels for electricity. These Maryland regulations, as a part of the larger RGGI regional process, would be among the first regulations of their kind in the country.

V. AFFECTED SOURCES[10]

These regulations affect fossil fuel-fired generating units at the following plants:

Owner	Plant	Location (County)	Fuel
AES Enterprise	Warrior Run	Allegany	Coal
Allegheny Energy	R P Smith	Washington	Coal
Con Edison Development & Old Dominion Electric Cooperative	Rock Springs	Cecil	Natural Gas
Constellation Power	Brandon Shores	Anne Arundel	Coal
	C P Crane	Baltimore	Coal
	Perryman	Harford	Oil/Natural Gas
	Riverside	Baltimore	Oil/Natural Gas
	Herbert A Wagner	Anne Arundel	Coal/Oil/Natural Gas
	Westport	Baltimore City	Natural Gas
Mirant	Chalk Point	Prince George's	Coal/Natural Gas
	Dickerson	Montgomery	Coal/Natural Gas
	Morgantown	Charles	Coal
Mittal Steel	Sparrows Point	Baltimore	Natural Gas/Blast Furnace Gas
New Page	Luke Mill	Allegany	Coal
NRG Energy	Vienna	Dorchester	Oil
Panda Energy	Brandywine	Prince George's	Natural Gas

VI. GREENHOUSE GASES

Atmospheric gases including CO_2, methane, nitrous oxide, hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF_6) are called greenhouse gases (GHGs) because they trap the sun's energy in the atmosphere close to the earth's surface as heat, similar to the glass panels of a greenhouse. They are emitted through a combination of human activities and natural processes as described below.

[10] Maryland Department of Natural Resources, Power Plant Research Program (PPRP), *Electricity in Maryland Fact Book*, August 2006, http://esm.versar.com/pprp/factbook/Fact%20bk%2006%20std.pdf, accessed, 12/10/07.

Carbon Dioxide

CO_2 is a gas emitted through the burning of fossil fuels such as oil, natural gas, and coal, and through the burning of solid waste, trees, and wood products. It is also cycled through natural systems. Carbon dioxide is produced naturally through the eruption of volcanoes and respiration of animals and plants. Plants use CO_2 in photosynthesis, converting energy from the sun into living matter such as leaves and branches. In addition, the oceans at their surface release CO_2 to the atmosphere and store CO_2 from the atmosphere.[11]

Since the Industrial Revolution in the 1700's, human beings have caused a significant increase in CO_2 levels in the atmosphere. The National Oceanic and Atmospheric Administration (NOAA) has indicated global CO_2 levels to be approximately 36% higher in 2005 than in pre-industrial times.[12]

Methane

Methane (CH_4) is emitted from the burning of fossil fuels as well as biomass, the cultivation of rice, the raising of livestock, and the management of waste. It also comes from natural sources such as wetlands, termites, oceans, permafrost, and wildfires.

Nitrous Oxide

Nitrous oxide (N_2O) also has human and natural sources. It is produced through the combustion of fossil fuels, animal manure management, sewage treatment, and agricultural soil management. Natural sources include wet tropical forests and biological materials in soil and water.

Fluorinated Gases

Fluorinated gases include hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF_6). These are emitted during industrial processes such as aluminum production, semiconductor manufacturing, magnesium production and processing, and electric power transmission.[13]

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[11] U.S. Environmental Protection Agency (EPA), Greenhouse Gas Emissions, http://www.epa.gov/climatechange/emissions/index.html#ggo, accessed 12/10/07.
[12] National Oceanic and Atmospheric Administration (NOAA), Earth Systems Research Laboratory, as quoted by the U.S. Environmental Protection Agency (EPA), http://www.epa.gov/climatechange/science/recentac.html#ref, accessed 12/10/07.
[13] U.S. Environmental Protection Agency, Greenhouse Gas Emissions, http://www.epa.gov/climatechange/emissions/index.html#ggo, accessed 12/10/07, and http://www.epa.gov/highgwp/sources.html, http://www.epa.gov/methane/sources.html, and http://www.epa.gov/nitrousoxide/sources.html, all accessed 12/10/07.

VII. ENVIRONMENTAL & HEALTH IMPACTS OF CLIMATE CHANGE

Summary

According to the International Panel on Climate Change (IPCC) in its 2007 Assessment Report, the evidence for human-influenced global climate change is "unequivocal."[14] Maryland's natural environments and its citizens are at great risk. According to the Maryland Department of Natural Resources (DNR), the state has close to 7,000 miles of tidal shoreline, making it highly vulnerable to increased sea level rise. This shoreline includes barrier islands and extensive low-lying land on the Eastern Shore and around the Chesapeake Bay. In addition, Maryland's air quality, water quality, plant and animal species, natural habitats, and industries for utilizing the State's natural resources, such as timber, and the overall quality of life of Maryland residents are at risk from climate change.

The IPCC models suggest, though, the possibility of mitigating some of the impacts of climate change. By reducing atmospheric levels of greenhouse gases, the world may see sea levels rise 1.5 feet rather than 3 feet. The risks of deterioration of the Greenland ice sheet, the melting of which influences sea levels as far away as Maryland, may be reduced significantly. Likewise, by reducing levels of greenhouse gases, the number of days of extreme heat stress may increase only slightly.[15]

Marylanders at Risk from Greenhouse Gas Emissions in Maryland

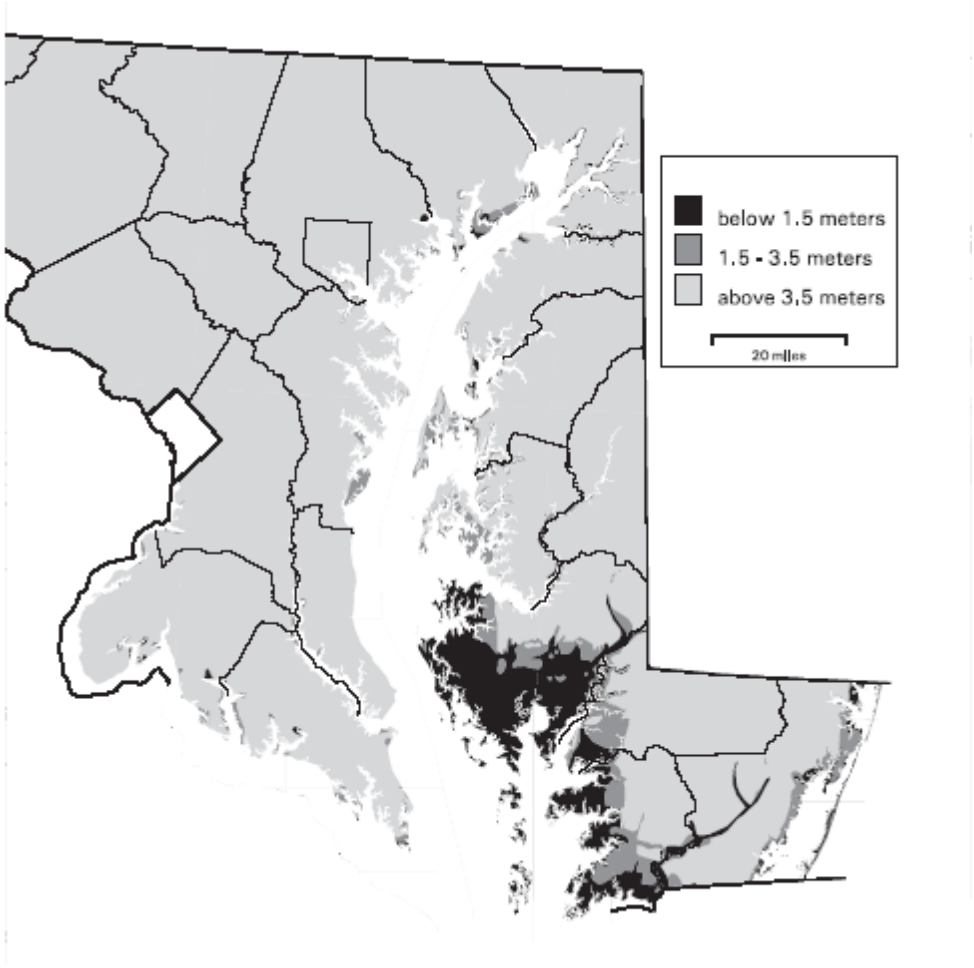
All Marylanders are at risk of economic and health impacts from greenhouse gas emissions in the State. Particularly threatened, though, are the residents who live in the coastal areas at the greatest risk of flooding (see "Maryland Coastal Areas Vulnerable to Sea-Level Rise," below). Maryland's coastal population increased by 1.2 million from 1980 to 2003, representing the eighth highest increase in a state's coastal population over this time period.[16]

In addition, those with limited financial resources, those with disabilities, and the elderly are likely to be at an increased risk of adverse effects from coastal flooding. In the case of Hurricane Katrina in 2005, the majority of those sheltered in New Orleans' Superdome

[14] International Panel on Climate Change (IPCC), Fourth Assessment Report, Synthesis Report, *Climate Change 2007*, http://www.ipcc.ch/ipccreports/ar4-syr.htm, accessed January 25, 2008.
[15] Maryland Climate Change Commission, *Interim Report to the Governor and the Maryland General Assembly: Climate Action Plan*, January 14, 2008.
[16] United States Department of Commerce, National Oceanic and Atmospheric Administration, National Ocean Service, Population Trends Along the Coastal United States, 1980-2008, by Kristen M. Crossett, Thomas J. Culliton, Peter C. Wiley, Timothy R. Goodspeed, September 2004, page 3.

and Convention Center, considered shelters of last resort, were poor.[17, 18] Also, more elderly residents died than members of other groups.[19] As far as overall impacts of climate change, Rajendra Pachauri, Chairman of the International Panel on Climate Change (IPCC), stated at the release of the IPCC report's summary for policymakers in April 2007, "It is the poorest of the poor... who are going to be the worst hit."[20]

Maryland Coastal Areas Vulnerable to Sea-Level Rise



The regions shaded black on the map above are some of the areas that could experience flooding at high tide if global warming causes the sea level to rise 2 feet in the next 100

[17] SignOnSanDiego.com, Union-Tribune Publishing Company, "Hurricane Katrina makes landfall on Louisiana coast as Gulf Coast braces for powerful storm," August 29, 2005, http://www.signonsandiego.com/news/nation/20050829-0530-hurricanekatrina.html, accessed 1/2/08.
[18] Washington Post, "Many Evacuated, but Thousands Still Waiting: White House Shifts Blame to State and Local Officials, September 4, 2005, http://www.washingtonpost.com/wp-dyn/content/article/2005/09/03/AR2005090301680.html, accessed 1/2/08.
[19] MSNBC, "Lost in the shuffle: Katrina leaves elderly evacuees displaced, disconnected, November 24, 2005, http://www.msnbc.msn.com/id/10180296/, accessed 1/2/08.
[20] Environment News Service, UN Climate Change Impact Report: Poor Will Suffer Most, April 6, 2007, http://www.ens-newswire.com/ens/apr2007/2007-04-06-01.asp, accessed 1/2/08.

years, as the IPCC estimates.[21] Tidal variations and land subsidence (the gradual settling or sinking of the land) would, along with global warming, contribute to the effect shown.[22]

The IPCC estimations do not take into account rapid changes in ice flow such as those that are now being chronicled in Greenland and Antarctica. Based on current trends, sea levels along Maryland's coastline may rise as much as 3 feet by the end of the 21st century, according to the Maryland Climate Change Commission's January 2008 *Interim Report*.

Maryland saw significant loss and shrinking of Bay islands and tidal wetlands in the twentieth century and additional loss of wetlands and islands would be likely with increased sea level rise. Similarly, additional salt water and sediment could intrude into the habitats of fish and wildlife of the Bay. This would lead to additional loss of marshes and other wildlife habitats. Marshland at Blackwater has already been lost due to rising sea levels since 1938.[23] In addition, the Chesapeake Bay has already warmed by about 2°F and continued warming would create complications in the extensive regional efforts to restore its health.[24]

Accelerated sea level rise due to global warming is expected to increase the frequency and magnitude of storms such as the 100-year storm, resulting in increased flood damage.[25] In addition, human settlements from coastal communities to the oldest parts of historic port cities will be at risk, particularly during storm surges.

Air and Weather

If greenhouse gas emissions are not sufficiently reduced, average summer temperatures in Maryland, based on the IPCC's global models, would increase by about 4°C (7°F) by the year 2100 and the number of days with temperatures greater than 90°F would be likely to quadruple, with 25 or more 100°F days.[26] The progress that Maryland has made in reducing smog and other air pollution could be reversed with these temperature increases. Increased temperatures from global warming, along with strong ultra-violet radiation (sunlight), stable air masses, and the presence of volatile organic compounds (VOCs) and

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[21] A two-foot sea level rise would represent more than twice the rate of sea level rise Maryland experienced during the 20th century, according to the Maryland Climate Change Commission, *Interim Report to the Governor and the Maryland General Assembly: Climate Action Plan*, January 14, 2008.
[22] J.G.Titus and C.Richman, 2000, "Maps of Lands Vulnerable to Sea Level Rise: Modeled Elevations Along the U.S. Atlantic and Gulf Coasts." Climate Research (2001), http://yosemite.epa.gov/oar/globalwarming.nsf/UniqueKeyLookup/SHSU5BUSSB/$File/mdbw.pdf, accessed 12/10/07.
[23] United States Environmental Protection Agency (EPA), Office of Policy, "Climate Change and Maryland," EPA 236-F-98 –0071, September 1998, http://yosemite.epa.gov/OAR/globalwarming.nsf/UniqueKeyLookup/SHSU5BUSTE/$File/md_impct.pdf, accessed 11/30/07.
[24] Maryland Climate Change Commission, January 14, 2008.
[25] Maryland Climate Change Commission, January 14, 2008.
[26] Maryland Climate Change Commission, January 14, 2008.

NO_X, enhance the formation of ground-level ozone. Increased concentrations of ground-level ozone promote respiratory illness in children, the elderly, and those with pre-existing illnesses.

More intense and prolonged periods of summertime heat can result in increased mortality and heat illnesses, especially in cities that experience the heat island effect. The term "heat island" refers to urban air and surface temperatures that are higher than nearby rural areas. Many U.S. cities and suburbs have air temperatures up to 5°C (10° F) warmer than the surrounding natural land cover.[27] The U.S. EPA reports that a one degree Fahrenheit (1° F) increase in average temperature could more than double heat related fatalities in cities like New York from 300 to 700 per year.[28] Similar effects could be seen in other large cities such as Baltimore and Washington, DC.

Average winter temperatures in Maryland, based on the IPCC models, would increase by approximately 4°C (8°F) by the end of the century. Precipitation during the winter and spring is likely to increase 10-15%, coming mostly in heavy rainfall events, but the summers and falls are likely to be drier as increased evaporation depletes soil moisture.[29]

Water Quality

The region's public water supply would be stressed by changes in temperature and precipitation. Approximately two-thirds of Maryland's 5.1 million citizens obtain water from rivers, streams, reservoirs, and other surface water sources. The amount of water available from these sources can be highly variable, for example, drought conditions occurred in Maryland in 1999 and 2002. Residential development and increased population in communities surrounding water supply areas is placing additional strain on the water supply, and predicted extended periods of drought from climate change would place additional stress on the system.

Large lakes and reservoirs that are critical not only as drinking water sources for Maryland, but also as a resource for electric power, flood control, recreational opportunities, and more, are threatened by global warming. Maryland's reservoirs include Rocky Gorge, Loch Raven Reservoir, Liberty Reservoir, Prettyboy Reservoir, Deep Creek Lake, Greenbrier Lake, Lake Linganore, and Conowingo Reservoir. Global warming is likely to lower the water levels of these and other lakes through increased evaporation. If studies of the Great Lakes are any indicator, Maryland may suffer a great impact from loss of its fresh water sources. Studies predict the average water levels to decrease from 1.5 to three feet for the Great Lakes within three decades.[30]

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[27] United States Environmental Protection Agency (EPA), Heat Island Effect, Basic Information, http://www.epa.gov/hiri/about/index.html, accessed January 30, 2008.
[28] United States Environmental Protection Agency. "Climate Change and New York." September 1997, page 3.
[29] Maryland Climate Change Commission, January 14, 2008.
[30] Slivitzky, Michel and Limno-Tech, Inc. Ecological Impacts of Water Use and Changes in Levels and Flows, June 2002, page 11.

Forests

Global warming would impact Maryland's forests and likely affect Maryland's wood industries, Chesapeake Bay coastal estuaries, recreational opportunities, and the overall quality of life in the state.

Currently, the total value of goods shipped from Maryland's wood industries is estimated at $2.6 billion per year, according to the Maryland Department of Natural Resources, and the forest industry is the top industry in Western Maryland and the number two industry on the Maryland Eastern Shore. Climate change could shift the current forest mix, predominantly maple and oak, to warmer mixed forests, particularly southern pines and oaks. Maryland currently has dozens of small, family-owned sawmills in the western areas as well as larger mills on the lower Eastern Shore. Approximately 50% of mill output is from pine trees. Maryland forests also supply wood pulp for three paper companies, one with a paper mill in the state, the other two with paper mills out of state.

Climate change might encourage the planting of loblolly pine farther south, a shift that would have some benefits and some detriments in Maryland. It would mean more wood available to Maryland mills on the Eastern Shore for primary processing but it would also mean less demand for the processed timber at New England facilities that carry out secondary processing to produce furniture and other products. Also, Western Maryland hardwood industry is reliant on the special mix of species found in Maryland forests, a southern extension of the Northern Appalachian forest including high quality timber such as white oak, northern oak, black cherry, basswood, and some hard maple. The industry in Western Maryland would likely suffer from a shift to a Southern Appalachian forest with lower quality oaks, poplars, and soft maples.

Changes in the frequency of storms, in association with climate change, could affect the hydrology and health of forests upland of the Chesapeake Bay, significantly affecting the coastal estuaries of the Bay in which commercial fish and shellfish live. Recreational activities such as bird watching, camping, and hunting in forests might also be impacted by climate change.

Furthermore, on another level, changes in forests and other ecosystems may impact peoples' quality of life and well being in ways that are very difficult to quantify.

Animal and Plant Life Cycles

Climate change will affect phenology, the timing of biological functions in relationship to climatic events. In wildlife, migration, breeding/spawning, hibernation, estivation, and the natural range of species are all likely to change in response to a shift in the climate, especially when flowering and fruiting in plants they feed upon also are changed. Some plants need low winter temperatures in order to reach optimal production of flowers and fruit during the growing season and may be impacted by increased temperatures.

In many cases, though, biological activities are ultimately triggered by non-climatic signals, such as day length, at the same time that temperature affects many natural processes. This combination would potentially result in wildlife populations attempting to reproduce or migrate at unfavorable times.[31]

Temperature also affects the range of a species; butterfly species in Europe and North America have already shifted their ranges northward. Some climate change models predict that the range of state birds, such as Maryland's Baltimore Oriole, may shrink or disappear from their state.[32]

In addition, severe weather effects besides coastal flooding and storm surges can harm fish and wildlife populations; for example, unpredictable and irregular droughts, tornadoes, and ice storms can stress wildlife and their habitats to a degree from which some species may not be able to recover.

Agriculture

Agriculture is likely to be affected by global warming. Major crops in Maryland include tomatoes, corn for grain, soybeans, hay, and wheat. Increases in temperatures, drought, and/or CO_2 levels are expected to affect yields of these and other crops. Increased CO_2 levels tend to lead to greater agricultural yields in some crops. In contrast, increased temperatures and drought tend to impact processes such as pollination and grain set. At temperatures above 33ºC (91ºF), these processes begin to fail.[33]

Dairy farmers would also be impacted since milk production is maximized under cooler conditions ranging from 41 to 68 degrees Fahrenheit.[34] Chicken farming is also a major industry in Maryland, and impacts would include increased energy costs for cooling the housing for chickens.

Insect- and Animal-Borne Disease

Increased temperature and precipitation levels produce conditions favorable for the introduction and spread of vector-borne illnesses such as Lyme Disease, Equine Encephalitis, West Nile Virus, and other diseases spread by mosquitoes, ticks, and wild

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[31] U.S. Climate Change Science Program, "The Effects of Climate Change on Agriculture, Land Resources, Water Resources, and Biodiversity," Public Review Draft of Synthesis and Assessment Product 4.3, Chapter 2, Agriculture, p. 6, updated 9/11/07, http://www.climatescience.gov/Library/sap/sap4-3/public-review-draft/sap4-3prd-agriculture.pdf, accessed 12/18/07.
[32] National Wildlife Federation, "Wildlife at Risk: Change the Forecast for Wildlife, Solutions to Global Warming, 2006, p.2, http://www.nwf.org/globalwarming/pdfs/WildlifeatRisk.pdf, accessed 12/18/07.
[33] U.S. Climate Change Science Program, updated 9/11/07, p.8.
[34] Garcia, Alvaro. Dealing With Heat Stress In Dairy Cows. South Dakota Cooperative Extension Service. September, 2002. Page 1.

rodents.[35] West Nile Virus and Equine Encephalitis are already present in mosquitoes in Maryland.

VIII. SECONDARY IMPACTS OF REGULATIONS

Leakage

"Emissions leakage" is a term used to refer to a shift in the generation of electricity and associated emissions from electric generators subject to the RGGI emissions cap to higher-emitting electric generators outside the RGGI region, after the initiation of the CO_2 Budget Trading Program on January 1, 2009. Leakage is likely to result from the implementation of the RGGI cap-and-trade program in the RGGI region due to the extra cost of electricity generation for sources under the RGGI cap compared to sources not subject to the cap.

RGGI has considered leakage to be a serious concern and, in response, established an Imports and Emissions Leakage Working Group in December 2005. In March 2007, the group drafted a preliminary report for the RGGI Agency Heads. The report, entitled "Potential Emissions Leakage and the Regional Greenhouse Gas Initiative (RGGI): Evaluating Market Dynamics, Monitoring Options, and Possible Mitigation Mechanisms," reviewed the leakage issue and potential solutions. The report recommended modifications to existing generation attribute tracking systems in the RGGI region in order to monitor emissions leakage. It also evaluated diverse policy options for addressing potential emissions leakage. These included policies to reduce electricity demand, a carbon procurement adder, a carbon procurement emissions rate, an emissions portfolio standard, and a load-based emissions cap.[36]

In 2008, the working group will provide to the commissioners and secretaries of the environmental and energy agencies in the RGGI states an update on the March 2007 report. Included will be documentation of the group's work with the three independent system operators (ISO) for the RGGI region: the New England, PJM, and New York ISOs. To help to address leakage, all three ISOs are working to add emissions and leakage tracking measures to their generation tracking systems. Implementation of these measures is expected by the end of 2008. The working group recommends policy options for reducing electricity demand as another means of reducing potential leakage. Finally, a federal CO_2 cap-and-trade program, an increasing prospect, would fully eliminate the problem of leakage.

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[35] National Assessment Synthesis Team (NAST), 2001: Climate Change Impacts On The United States, The Potential Consequences of Climate Variability and Change. Page 450.

[36] See Regional Greenhouse Gas Initiative (RGGI), "Potential Emissions Leakage and the Regional Greenhouse Gas Initiative (RGGI): Evaluating Market Dynamics, Monitoring Options, and Possible Mitigation Mechanisms," Initial Report of the RGGI Emissions Leakage Multi-State Staff Workgroup to the RGGI Agency Heads, March 14, 2007, http://www.rggi.org/docs/il_report_final_3_14_07.pdf.

IX. ECONOMIC ANALYSIS

Expected Costs to the Regulated Entity & the General Public from the Regulations[37]

The regulations establish the MD CO_2 Budget Trading Program with which all fossil fuel-fired generators of at least 25 Megawatts must comply. There are no costs to generators for additional pollution prevention equipment to reduce CO_2 emissions since current technology has not reached this level of development. Instead, generators must purchase, either through auction, secondary market or directly from the Department, one allowance for each ton of CO_2 emitted for each three-year period, beginning 2009.

The money received by the auction and/or sale of allowances will go into the Clean Air Fund or any other fund authorized by the legislature. The funds will then be used to support energy efficiency, directly mitigate electricity ratepayer impacts, promote renewable or non-carbon emitting energy technologies, stimulate or reward investment in the development of innovative carbon emissions abatement technologies with significant carbon reduction potential, and administer these regulations.

This economic impact analysis primarily focuses on an estimate of the overall costs to implement these regulations. In this regard, a number of economic analyses have been considered, including economic evaluation of auction platforms and auction percentages by private consultants.

The University of Maryland's Center for Integrative Environmental Research (CIER) conducted an initial study released in January 2007 to evaluate the economic impact on affected sources and rate-payers and the economic welfare of the state with implementation of these regulations. The study was based on certain assumptions, including that all RGGI states would auction only 25% of allowances and allocate the rest to generators. The study concluded that the RGGI model rule would have limited impact on the economy and electric power markets in Maryland. Specifically the study projected the following: [38]

1) Net electricity demand in-state would be lowered by between 1.5 percent in 2010 and close to 3 percent in 2025 relative to baseline demand (see the section "Energy Supply," pages 25-40 of the report);

2) Maryland would reduce exports of electricity to neighbors and increase reliance on imports from out of state. Reducing exports would cause in-state coal and natural gas electric generation to be reduced (see "Energy Supply Study," pages 25-40);

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[37] Also see Appendix I: Emissions In Maryland, 2000-2002, in this document.

[38] Center for Integrative Environmental Research (CIER), University of Maryland, College Park, in collaboration with Resources for the Future, The Johns Hopkins University, and Towson University, "Economic and Energy Impacts from Maryland's Potential Participation in the Regional Greenhouse Gas Initiative," January 2007, http://www.cier.umd.edu/RGGI/documents/UMD_RGGI_STUDY_FINAL.pdf, accessed January 23, 2008.

3) There would be no increased retirement of existing generating capacity but there would be a negative effect on the profits of existing generators, particularly coal-fired generators. Each fossil fuel-fired unit required to purchase annual allowances to cover CO_2 emissions could spend in excess of several million dollars (see "Energy Supply Study," pages 25-40);

4) There would be virtually no effect on the price of electricity paid by rate-payers in Maryland (see "Electricity Rate Study," pages 64-67, and "Economic Welfare Study," pages 67-77); and

5) There would be no evidence that the effects of these regulations will amplify any potential market power in the generation market (see "Generator Competitiveness Study, pages 42-50).

At least five participating RGGI states have documented their intentions to auction 100% of their allowance allocations with no allocation of allowances to generators. To address this, the CIER, in conjunction with Resources for the Future (RFF), will release a second study in February 2008, which builds on the January 2007 research but varies assumptions for the allowance percentage sold at auction in Maryland and the amount of revenue used to fund energy efficiency. Preliminary conclusions from the 2008 study include:[39]

1) Electricity prices will fall by about 0.25% for each additional 25% of allowance value used to fund demand efficiency measures;

2) Each additional increment of spending on energy efficiency will reduce power imports by about 3% and lower the price for allowances by about 2.5% to 5.5%;

3) No large shifts in Maryland's generation capacity are expected no matter what is the funding level for demand efficiency;

4) No large shifts are expected in the mix of fuels used by Maryland to produce power;

5) Generators will experience lower profits as a result of their need to purchase allowances and from reductions in electricity demand resulting from investments in end-use efficiency; reduced profits will not be enough to effect significant change in the generation capital stock;

6) Losses borne by power producers will be more than offset by the gains of electricity consumers; and

7) Increased funding for end-use energy efficiency will result in reduced emissions and greater economic surplus.

[39] Resources for the Future, "Additional Model Analysis of Maryland Joining RGGI," Memorandum to Maryland Department of Natural Resources' PPRP, Maryland Department of the Environment, and Exeter Associates, September 18, 2007.

Expected Costs to the State

The complete economic impact to the Department, depending on numerous factors, can only be estimated. Based on CIER research, these regulations are predicted to have a positive economic impact on the gross state product of approximately $100 million in 2010, increasing to about $200 million in 2015 and subsequent years. Also, approximately 1,200 jobs are expected to be created by 2010 across the state, increasing to 2,800 jobs by 2025.

The auction cost per allowance is not known at this time and could range from pennies per allowance to a cost of $5 - $10 per allowance. Auction or sale of 100% of allowances at $3 per allowance, the price suggested by market researchers, would result in $112,512,000 annually, and $7 per allowance would result in $262,528,000 annually. A $0.25 cost per allowance (100% of allowances) would generate $9,376,000 annually.

APPENDIX I: EMISSIONS IN MARYLAND, 2000-2002

Generators with a Nameplate Capacity of Greater than 25 mW: Historical Emissions Estimates for 2000-2002[1]

3/8/2007

(All figures in short tons carbon dioxide)

Merchant Generators	**2000**	**2001**	**2002**	**Avg 2000-02**
Brandon Shores	9,643,560	9,260,989	7,573,937	8,826,162
CP Crane	2,447,539	2,527,698	2,446,256	2,473,831
Chalk Point	5,309,318	5,227,809	6,422,583	5,653,237
Dickerson	2,962,099	3,144,971	3,182,191	3,096,420
Gould Street (This location has since been shut down; however, Rock Springs, with a similar capacity, has come on line.)	109,334	204,519	209,193	174,349
Herbert A Wagner	3,653,742	3,334,405	3,220,518	3,402,888
Morgantown	7,592,457	7,089,964	7,469,691	7,384,037
Perryman	75,049	218,588	114,537	136,058
R P Smith	624,407	608,321	618,455	617,061
Riverside	20,518	51,775	45,458	39,250
Vienna	304,411	193,554	287,152	261,706
Westport	11,642	7,283	2,855	7,260
Merchant Generator Unit Subtotals	**34,776,529**	**33,571,588**	**33,272,434**	**33,873,517**
Long-Term Contract Generators	**2000**	**2001**	**2002**	**Avg 2000-02**
AES Warrior Run	1,536,726	1,599,235	1,570,012	1,568,658
Panda Brandywine	485,727	102,476	109,598	232,600
Long-Term Contractor Unit Subtotals	**2,022,453**	**1,701,711**	**1,679,610**	**1,801,258**

Generators with a Nameplate Capacity of Greater than 25 mW:
Historical Emissions Estimates for 2000-2002[1]

3/8/2007

Industrial Generators[3]	**2000**	**2001**	**2002**	**Avg 2000-02**
New Page Total	1,039,679	979,751	1,073,729	1,031,053
Mittal Steel Total[4]	2,632,646	2,431,214	2,740,381	2,601,414
Industrial Unit Subtotals[2]	**3,672,325**	**3,410,965**	**3,814,111**	**3,632,467**
Mittal Total CO2 w NG=BFG Factor	**689,431**	**616,796**	**707,300**	
Total	**38,448,854**	**36,982,034**	**37,086,545**	**37,505, 984**

[1]Estimates based upon available EPA, EIA, and State data
[2]These 2 cogeneration sources are located at industrial manufacturing facilities. Under a RGGI option, sources for which gross output to the grid is less than 10% can be exempted from an emissions cap if such units accept restrictions upon their generation.

[3]Figures reflect estimates using blast furnace gas emission factor of about 495 lbs CO2/mmBtu, which is about 4 times higher than that of natural gas (US DOE: Energy and Environmental Profile of the U.S. Iron and Steel Industry, August 2000. Using a natural gas factor would decrease the total by about 1.8 million tons.

APPENDIX II: SALT MARSH OFFSET PROJECT

MARYLAND
DEPARTMENT OF
NATURAL RESOURCES

Martin O'Malley, Governor
Anthony G. Brown, Lt. Governor
John R. Griffin, Secretary
Eric Schwaab, Deputy Secretary

Background for New Offset Category:
Carbon sequestration through salt marsh restoration and conservation

Maryland Salt Marshes

Tidal marshes are important for estuarine ecosystems such as Maryland's portion of the Chesapeake Bay, serving as critical habitats for wildlife and as buffers to large storm events. In addition, tidal marsh soils have the capacity to sequester large amounts of carbon as they accrete with sea-level rise (Hussein et al., 2004). The balance of sea-level rise and sediment deposition rates affect the long-term sustainability of tidal marshes and their ability to store carbon (Slocum et al., 2005). The U.S. Fish and Wildlife Service and the U.S. Army Corps of Engineers are investigating the use of clean dredged sediments from the shipping channels in the Chesapeake Bay to restore and rebuild tidal marshes within the Blackwater National Wildlife Refuge and surrounding lands in Dorchester County (Integration and Application Network, 2007). Approximately 20,000 acres of productive marsh area has been lost in and around the Refuge over the last several decades.

Carbon Value of Restoration

Tidal marshes are among the most productive ecosystems on earth, with production variability related to solar radiation inputs and nutrient availability (Mitsch and Gosselink, 2000). In conditions of rising sea levels, they can be significant carbon sinks through organic and mineral accretion (Rabenhorst, 1995). However, marsh decline is widespread, with a corresponding decrease in carbon flux over time (Kearney et al., 2002). Artificial sediment deposition can be used to restore marshes allowing them to regain health and stimulate organic matter deposition (Slocum et al, 2005).

Tidal marshes represent a significant pool in the global carbon cycle (e.g., Chmura et al., 2003; Rabenhorst, 1995). In a comprehensive review, Chmura et al. (2003) estimated the average salt marsh carbon density of 0.039 g cm^{-3}. In the Chesapeake Bay, Kearney and Stevenson (1991) found carbon densities of 0.040, 0.027, and 0.044 g cm^{-3} for three locations with varying deposition regimes. Tidal marsh soils can contain three to ten times more C than

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upland soils (Rabenhorst,1995). The potential for additional carbon storage, or sequestration, is large because there is high primary productivity and increases in soil thickness as sea level rises (Chmura et al., 2003). Carbon sequestration rates may range from 0.05 to 0.5 kg C m^{-2} yr^{-1}. Furthermore, tidal marshes present a unique situation in which organic peat can accumulate without significant methane production. In salt and brackish marshes, abundant sulfate supplied by tidal action limits CH_4 production (Hussein and Rabenhorst, 1999). Studies of gas fluxes have indicated that in most cases these soils are negligible sources of CH_4 (Bartlett and Harris, 1993; Magenheimer et al., 1996) creating interest in their use for C sequestration efforts.

Accounting Issues

In order for tidal marsh restoration to be successful, the new marsh surface must accrete with sea level rise. As marsh accretion is a function of organic matter accumulation and the sedimentation of mineral and organic materials, monitoring of organic and mineral matter accretion is a key variable controlling the long-term sustainability of a restoration project. An accounting of carbon within organic matter (approximately 50% of the organic matter by mass) is also necessary for global carbon cycle monitoring and for the crediting of carbon sequestration through marsh conservation and restoration. Carbon accounting requires estimation of carbon dynamics both vertically and laterally with sufficient replication to obtain statistical confidence depending on the variability of the marsh. Carbon content accounting requires estimation of the dynamics of soil carbon concentrations and density and changes in soil volume. Carbon concentrations and densities are correlated due to the negative correlation between organic matter concentration and soil bulk density. Soil volumes are variable over time in marshes due to vertical accretion and consolidation. A common means to assess vertical accretion is through the establishment of surficial marker horizons (Cahoon et al, 2002). Carbon dynamics beneath the marker horizon must also be accounted for due to root biomass deposition and organic matter decomposition (Edwards and Mills, 2005; Saunders et al., 2006). If a continuous stable subsurface horizon is present, such as a contrasting mineral layer, it may be used as a subsurface marker horizon. Elevation changes through regional, local, and root-zone subsidence complicate accretion monitoring and require specialized equipment for monitoring such as surface elevation tables (SETs).

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APPENDIX III: URBAN TREE CANOPY OFFSET PROJECT

MARYLAND
DEPARTMENT OF
NATURAL RESOURCES

Martin O'Malley, Governor
Anthony G. Brown, Lt. Governor
John R. Griffin, Secretary
Eric Schwaab, Deputy Secretary

Urban Tree Canopy
Fact sheet for MDE RGGI Technical Support Document

Forest or tree cover has often been used as a metric for environmental quality. This is an important indicator because "… gains and losses in forest area directly affect the public's continued enjoyment of the goods and services that forests provide—recreation, lumber, watershed protection, and many other things[a]". The term "forest resource assessment" is inclusive of urban areas, referring to the overall goal of maintaining adequate forest cover and stocking and includes assessments of forests "…on 'other wooded land' and as 'trees outside forests' – to support the social, economic and environmental objectives related to forestry within a country or region[b]."

Urban forests have two principal effects on greenhouse gas emissions:

- Carbon sequestration through increase in biomass; and,
- Avoidance of emissions through energy conservation.[c]

The avoidance benefit is greatest, followed by the sequestration value; not only on an offset per dollar basis,[d] but also due to the fact that avoidance is preferable to emission and capture.[e]

Due to very high land values in Maryland, afforestation has limited, if any, utility as an offset as the long-term protection requirement means not just maintaining the trees but prohibiting any other land use during the credit period. In addition, afforestation can only provide the lesser of the two benefits listed above (sequestration but not avoidance). UTC as an offset allows for credit for trees on improved lands, limiting the economic equation to only the cost of the tree and not to the tree as well as the value of the land beneath it.

Provision of credit for Urban Tree Canopy (UTC) will allow facilities obtaining offsets to make investments in communities, where most ratepayers reside, allowing utilities to make positive reinvestments in the community while meeting their mitigation requirements.

UTC has the environmental co-benefits of mitigating ozone (UTC is in the ozone non-attainment SIPs for Baltimore[f] and Washington DC[g] as a voluntary, innovative measure) by reducing the heat island effect and raising chemical mixing height, and of aiding Chesapeake

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Bay goals of improving water quality and storm water management by increasing UTC in communities across the state.[h]

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