A Blueprint for Action

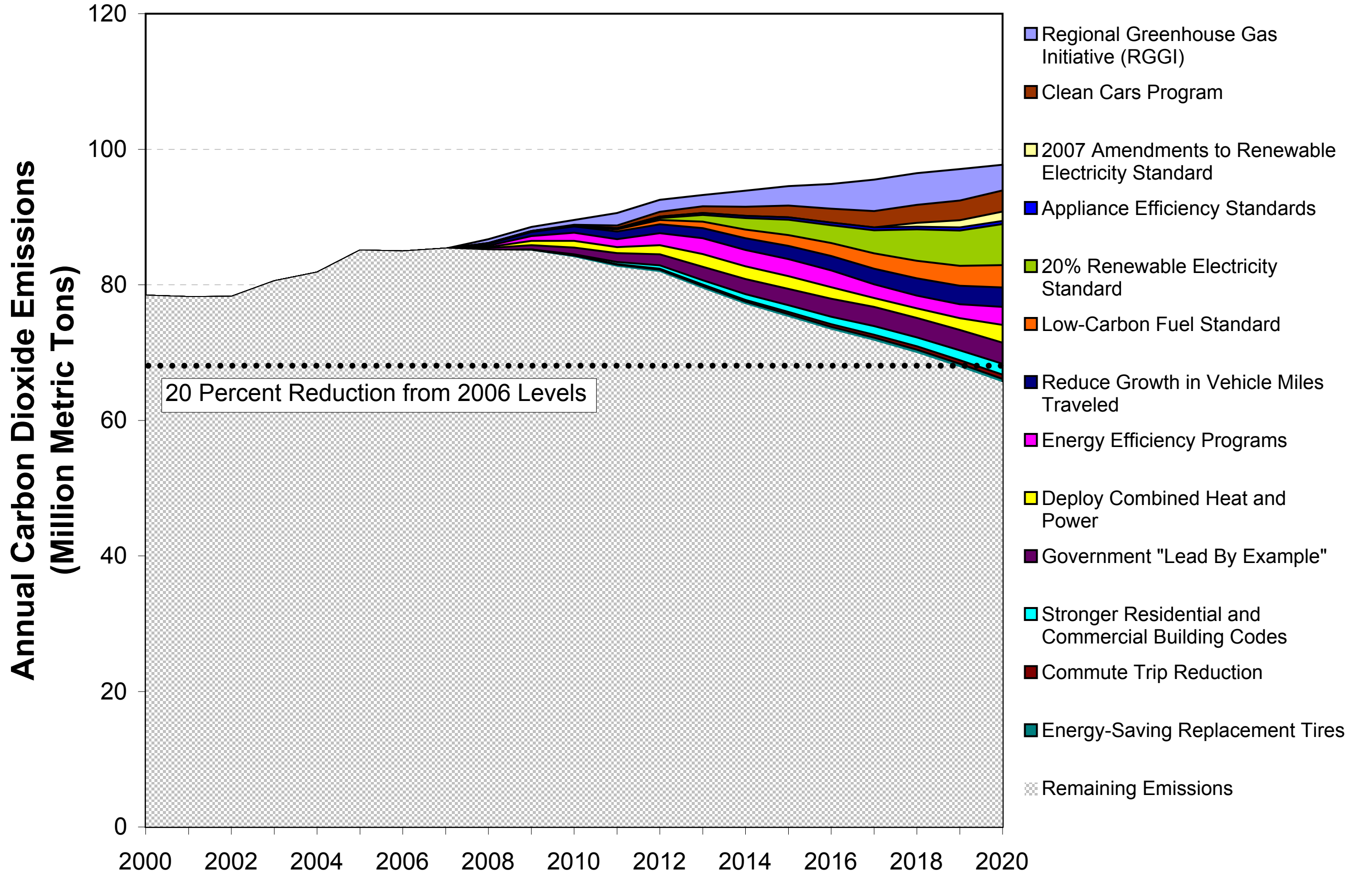
Policy Options to Reduce Maryland's Contribution to Global Warming




Environment Maryland
Research and Policy Center

June 2007

Carbon Dioxide Emissions in Maryland With Recommended Policies



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Executive Summary

Global warming poses a serious threat to Maryland's future well-being and prosperity. To avoid the worst impacts of global warming, Maryland needs to reduce its global warming pollution 20 percent by 2020 and 80 percent by 2050, setting an example for the rest of the nation to follow.

Thankfully, many technologies and policy tools exist that could substantially reduce Maryland's contribution to global warming, while moving the state toward a clean, secure energy future. Maryland has already taken several significant steps to cut its global warming pollution, but vast opportunities to further reduce emissions remain.

This report details nine policy strategies, in addition to four steps already taken, that would cut Maryland's emissions of carbon dioxide—the leading greenhouse gas—by 23 percent below 2006 levels by 2020. Adoption of these strategies will put Maryland on course to reducing its contribution to global warming in line with what scientists believe will be necessary to prevent catastrophic climate change.

Global warming is happening now and poses a serious threat to Maryland's future.

- Global average temperatures increased by more than 1.4° F in the past century. Sea level is rising, ice and snow cover are decreasing, and storm intensity has increased.

- According to the consensus view of the scientific community, human activity—particularly the burning of fossil fuels—is the primary cause of global warming. Fossil fuel consumption releases carbon dioxide, which traps radiation from the sun near the earth's surface. Since 1750, the concentration of carbon dioxide in the atmosphere has increased by 35 percent—leaving the concentration of carbon dioxide in the atmosphere higher than it has been in the last 650,000 years.

- World average temperatures could increase by another 3 to 7° F above late

20th century levels by the end of this century, depending on future emissions of global warming pollutants. Sea level could rise by between 11 and 17 inches, threatening low-lying coastal areas. And the ecological balance upon which life depends would be irrevocably altered.

- Maryland, with its 3,100 miles of tidally influenced coastline, is highly susceptible to negative impacts from global warming. For example, sea level rise could inundate thousands of acres of land over the next century, while increasing vulnerability to coastal flooding from major storms.

Immediate action is needed to prevent the worst impacts of global warming. Scientists tell us that if we act quickly and aggressively to reduce global warming emissions there is a much greater chance of staving off the worst impacts of global warming. To keep global temperatures from rising by more than 2.0° C (3.6° F), the world will need to halt the growth of global warming pollution in this decade, begin reducing emissions soon, and slash emissions by more than half by 2050. Because the United States is the world's largest global warming polluter, the degree of emission reductions required here will be greater than in less-developed countries.

By making a commitment to reducing global warming pollution and setting in motion the changes that will meet that target, Maryland can reduce its own significant contribution to global warming while encouraging others to do the same.

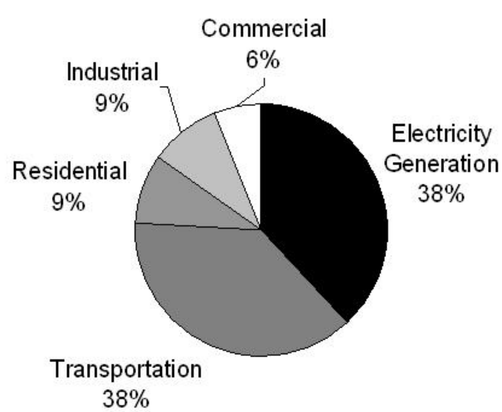
Emissions of global warming pollution are on the rise in Maryland.

- Between 1990 and 2004, Maryland's emissions of carbon dioxide from energy use increased by 16 percent. Electricity generation and transportation are the biggest sources of carbon dioxide pollution in the state (38 percent each), followed by the direct use of fossil fuels in homes (9 percent), industry (9 percent) and businesses (6 percent). (See Figure ES-1.) Maryland also produces emissions through the consumption of electricity generated in other states.

- Maryland is on a path that will lead to significant increases in global warming emissions over the next several decades. According to a projection based on data from the U.S. Energy Information Administration (EIA), Maryland's emissions of carbon dioxide from energy use could increase by 19 percent over 2004 levels by 2020, with increases in emissions from the transportation sector responsible for the bulk of emissions growth.

Maryland has already committed to several actions that will curb the growth of carbon dioxide emissions by 2020. Over the past several years, Maryland has taken important steps to limit global warming emissions from power plants and cars and to increase the use of renewable energy

Figure ES-1. Maryland Carbon Dioxide Pollution by Sector, 2004



for electricity generation. Maryland's renewable electricity standard requires that 9 percent of the electricity sold in the state in 2020 come from renewable sources. In 2006, the state joined a regional agreement that power plants reduce their global warming pollution by 10 percent by 2019. Most recently, the state adopted standards that will reduce global warming pollution from new cars and light trucks by an average of 30 percent.

Maryland could reduce its contribution to global warming much further by adopting nine key policy strategies. There are numerous tools available to Maryland to reduce global warming pollution. The following policies can help the state reduce carbon dioxide emissions from energy use.

1. Strengthen the renewable electricity standard. Maryland should increase its existing renewable electricity standard to require that 20 percent of electricity comes from renewable sources by 2020.

2. Adopt a low-carbon fuel standard. A portion of motor fuel sold in Maryland should come from sources with lower life-cycle emissions than gasoline or diesel to reduce the carbon intensity of the fuel mix by 10 percent by 2020.

3. Reduce the growth in vehicle miles traveled. Measures to reduce sprawling development and encourage the use of transit and other transportation alternatives could stop the per-capita growth in vehicle miles traveled by cars and light trucks on Maryland's highways.

4. Establish an energy efficiency goal. Spending 3 percent of electric utility revenues on energy efficiency each year would reduce electricity demand by 6.5 percent in 2020.

5. Encourage combined heat and power. Maryland has the potential for 1,900 MW more of combined heat and power technology, which allows commercial and industrial facilities to use the same energy to generate both electricity and heat for buildings.

6. Reduce government energy use. Maryland should increase the energy efficiency of existing state government by 25 percent and of new buildings by 50 percent, purchase at least 25 percent clean electricity in government buildings, and purchase efficient vehicles.

7. Strengthen building energy codes. Stronger energy codes for residential and commercial buildings would reduce energy use and thus global warming pollution.

8. Reduce the number of automobile commutes. Large employers should be required to develop programs to discourage single-passenger commuting and provide employees with more transportation choices to cut single-occupant vehicle commutes by 20 percent by 2020.

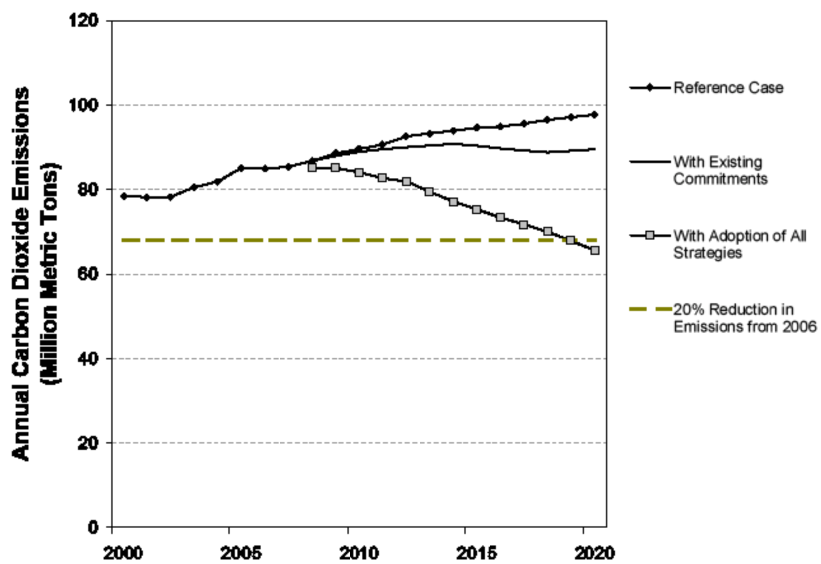
9. Require energy-saving replacement tires. By requiring the sale of energy-saving replacement tires, Maryland can improve vehicle efficiency without negatively affecting safety.

Adoption of these strategies would reduce global warming pollution while improving Maryland's energy efficiency. (See Table ES-1, Figure ES-2, and inside front cover.) By 2020, Maryland's emissions of carbon dioxide would be approximately 23 percent below 2006 levels.

Table ES-1. Emission Reductions from the Policies (million metric tons of carbon dioxide)

Policy	2010	2020
Commitments Already Made		
Regional Greenhouse Gas Initiative	0.6	4.6
Clean Cars Program	0.1	3.5
2007 Amendments to Renewable Electricity Standard	0.0	0.8
Appliance Efficiency Standards	0.1	0.4
Recommended Policies		
Expanded Renewable Electricity Standard	0.0	4.8
Low-Carbon Fuel Standard	0.0	3.7
Reduce Growth in Vehicle Miles Traveled	0.9	3.3
Energy Efficiency Programs	1.5	3.1
Deploy Combined Heat and Power	1.3	2.6
Government "Lead By Example"	0.9	2.0
Stronger Residential & Commercial Building Codes	0.1	1.3
Commute Trip Reduction	0.0	0.7
Energy-Saving Replacement Tires	0.3	0.6
Total Savings (including actions already taken)	5.5	32.1
Savings needed to achieve 20 percent reduction by 2020		29.8

Figure ES-2. Maryland's Carbon Dioxide Emissions from Energy Use after Adoption of Recommended Strategies



Maryland should commit to reducing its emissions of global warming pollutants to levels consistent with those scientists believe are necessary to avoid catastrophic climate change. Specifically, the state should:

- Commit to achieving reductions in global warming emissions of 20 percent by 2020 and 80 percent by 2050. Governor O'Malley has created a task force to recommend a reduction target. Adoption of a strong cap on global warming emissions would ensure that Maryland begins to reduce its emissions now.

- Ensure the full implementation of emission-reduction policies already adopted.

- Adopt the nine additional strategies recommended in this report.

- Take additional actions to reduce global warming pollution, including:

  - Strengthen the Regional Greenhouse Gas Initiative by working with other northeastern states to achieve greater reductions in carbon dioxide emissions from electric power plants.

  - Investigate options for additional policies to reduce global warming pollution, especially in areas not directly addressed in this report, such as emissions from air travel and industrial energy use and emissions of global warming pollutants other than carbon dioxide.

Introduction

Maryland is vulnerable to the threat posed by global warming. For example, as temperatures increase, sea level will rise and storms are likely to become stronger. With 3,100 miles of tidal shoreline, Maryland could lose hundreds of acres of land to the ocean every year, and suffer increased damage from major storms. A storm like Hurricane Isabel, which caused approximately $500 million in damage to the state, would be much more serious after a significant rise in ocean level.

Global warming will bring with it many other ecological and economic threats. A recent study by Nicholas Stern, head of the British Government Economics Service and former World Bank chief economist, estimates that inaction on global warming will cost the equivalent of 5 to 20 percent of worldwide economic output.[1] Maryland's share of this economic damage is unknown.

Fortunately, Maryland still has time to act. Cutting emissions of pollutants that trap heat in the earth's atmosphere will set Maryland on a path to avoid the worst impacts of global warming.

Taking action will also create economic and social benefits for the people of Maryland. Maryland's economy will grow as the state invests in renewable energy research, develops its renewable energy manufacturing capacity, and implements energy efficiency measures. Reducing the amount of fossil fuel (especially petroleum) consumed in Maryland will keep more dollars local and support the state's economy.

A recent study by the Baltimore-based International Center for Sustainable Development, funded by the state Department of Business and Economic Development, found that developing Maryland's clean energy industries—the very industries that will help the state reduce its global warming pollution—could create 144,000 jobs over the next 20 years, provide $5.7 billion in wages and salaries, boost state and local tax revenues by $973 million, and increase gross state product by $16 billion.[2]

As Maryland develops and deploys new and improved technologies—from advanced vehicles to highly efficient appliances to combined heat and power systems—the state will be in a better position to achieve greater reductions in emissions in the decades to come.

Making these changes will require an unprecedented amount of research, discussion, cooperation and political will. By using existing technologies and reasonable public policy tools, Maryland can reduce the state's contribution to global warming, while in many cases improving public health, economic well-being and energy security, and providing a model of leadership for others to follow.

The strategies laid out in this report show the way forward.

Global Warming and Maryland

Global Warming Is Happening

Global warming threatens Maryland's future health, well-being and prosperity. The first signs of global warming are beginning to appear in Maryland and throughout the world. Global temperatures and sea level are on the rise. Other changes, such as the recent increase in the severity of hurricanes, are consistent with the impacts scientists expect to occur on a warming planet and are harbingers of the dramatic climate shifts that await us if global warming pollution continues unabated.

Rising Global Temperatures

Over the last century, global average temperatures have increased by 1.3° F.[3] Scientists believe that temperatures in the last half of the 20th century were likely the highest in the last 1,300 years.[4] Since 1975, temperatures have been increasing at a rate of about 0.4° F (0.2° C) per decade.[5] Of the 12 warmest years (in terms of land and sea temperatures) since record-keeping began in 1850, 11 have occurred since 1995.[6]

Global warming appears to have intensified in recent years. The rate of warming in the past 50 years is twice that of the past 100 years.[7]

This warming trend cannot be explained by natural variables—such as solar cycles or volcanic eruptions—but is successfully predicted by models of climate change that include human influence.[8]

Less Snow and Ice

Snow cover in the Northern Hemisphere has declined over the last several decades, dropping by 5 percent during the 1980s.[9] (See Figure 1.) Glaciers are retreating around the globe and the annual extent of Arctic sea ice has declined by 2.7 percent per decade since 1978.[10]

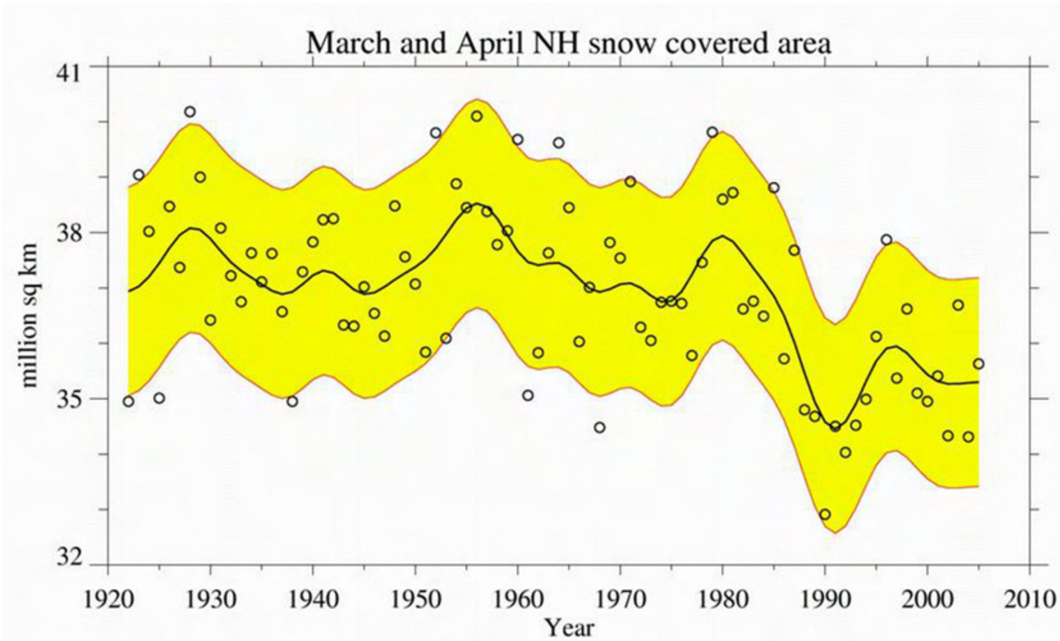
Rising Sea Levels

Over the course of the 20th century, average sea level increased by approximately 6.7 inches worldwide.[12] Sea level has risen more quickly in recent years.

More Severe Storms

Storms may be getting more intense and extreme rainfall events are becoming more common. For example, an increase in the fraction of rainfall occurring as heavy precipitation events has been observed, a

Figure 1. Trends in Northern Hemisphere Snow Cover[11]



potential result of warmer air that is able to hold more moisture.[13]

In addition, hurricanes appear to have become more powerful and more destructive over the last three decades, a phenomenon that some researchers link to increasing global temperatures.[14] The number of Category 4 and Category 5 hurricanes has increased substantially worldwide over the last 35 years.[15]

Shifting Seasons and Species on the Move

Worldwide, spring events—such as leaf unfolding, egg laying and bird migration—are occurring earlier in the year. In addition, numerous species of plants and animals appear to be moving toward the poles, likely in response to rising temperatures.[16]

Climate Change in Maryland

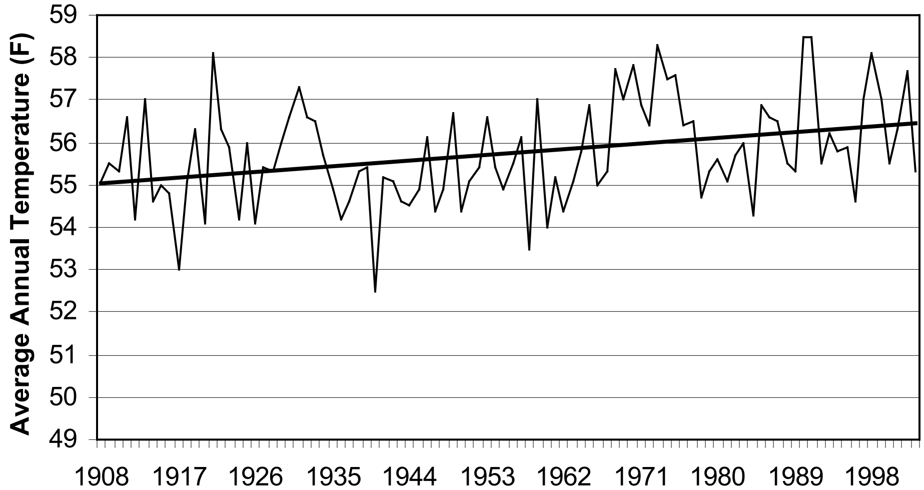
Maryland's climate has changed significantly over the past century.

Maryland has been getting hotter and wetter. The average temperature in College Park has risen by 2.4° F in the past 100 years.[17] Data from five of eight temperature stations across the state show increasing temperatures from 1948-1999 and all eight stations show increasing temperatures from 1977-1999.[18] Precipitation has increased by 10 percent in many parts of the state.[19]

Figure 2 (next page) shows the annual mean temperature from a weather station near Waldorf, Maryland. From 1908 to 2003, average recorded temperature has risen by more than a degree.

Sea level is rising. Sea level near Baltimore has risen 7 inches in the past 100 years.[21] Maryland's vulnerability to sea rise is exacerbated by a separate trend: the state is sinking by more than 6 inches per century as it recovers from glaciers that covered the region thousands of years ago.[22] The net effect of rising sea levels and sinking land has

Figure 2. Annual Mean Temperatures in Maryland[20]



been a 1-foot increase in water level in the past 100 years, and along Maryland's 3,100 miles of tidally influenced shoreline, the loss of 260 acres of land each year.[23] Thirteen islands in the bay have disappeared.[24] Smith Island has lost 30 percent of its land area since 1850 and 1,400 acre Poplar Island has disappeared almost entirely.[25]

Higher sea level increased the impact of Hurricane Isabel in 2003. Hurricane Isabel followed the same path and had roughly the same power as a storm in 1933.[26] That earlier storm, however, caused far less damage, in part because ocean levels were lower. Higher water levels in the bay allow water to be pushed farther inland, causing greater flooding damage, and also increase the strength of waves. In relatively shallow Chesapeake Bay, a 1-foot increase in water level produces a 40 percent increase in wave power.[27]

Human Activities Are Causing Global Warming

According to the consensus view of the world scientific community, human activity is the primary cause of global warming.

The Greenhouse Effect

Global warming is caused by human exacerbation of the greenhouse effect. The greenhouse effect is a natural phenomenon in which gases in the earth's atmosphere, including water vapor and carbon dioxide, absorb infrared radiation emitted from the earth's surface and subsequently heat the atmosphere and warm the surface—much like a blanket wrapped around the earth. The greenhouse effect is necessary for the survival of life; without it, temperatures on earth would be too cold for humans and other life forms to survive.

However, humans have altered the composition of the atmosphere in ways that intensify the greenhouse effect. Primarily by burning fossil fuels, humans have increased the levels of greenhouse pollutants in the atmosphere—especially in the period since the industrial revolution. Burning fossil fuels creates carbon dioxide, the primary global warming pollutant. (See "Global Warming Pollutants," p. 16, for a description of the types of pollution that contribute to global warming.)

Since 1750, the concentration of carbon dioxide in the atmosphere has increased by more than 35 percent.[28] Carbon dioxide levels are now increasing faster than at any time in more than 10,000 years, and are higher now than at any point in more than 650,000 years.[29] Concentrations of other global warming pollutants have increased as well. (See Figure 3.)

Global Warming Will Have Severe Impacts—Unless We Act Now

Should emissions of global warming pollutants continue to increase, the world will experience dramatic warming over the next century and beyond, with major impacts on the environment, the economy and on human health.

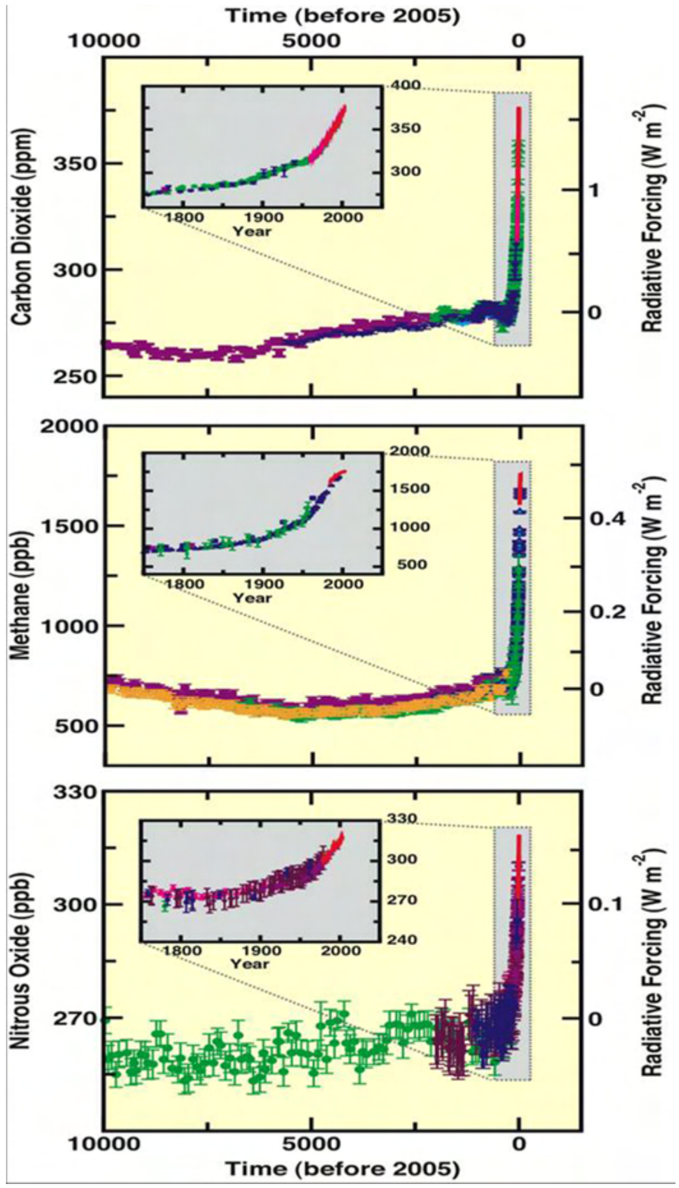
The Intergovernmental Panel on Climate Change (IPCC), the world's leading authority on the science of global warming, recently updated its projections about the future course of global warming. Among their findings:

- Global average temperatures will continue to increase at a rate of 0.4° F per decade over the next two decades. About half of this increase in temperature is essentially "locked in" as a result of pollution already emitted.

- World average temperatures could increase by another 3 to 7° F above late 20th century levels by the end of this century, depending on future emissions of global warming pollutants.[35] At the highest emission scenario evaluated by the IPCC, estimates of warming range between 4.3 and 11.5° F. (See Figure 5, p. 17.)

- World average sea level could be expected to rise by another 11 to 17 inches over the next century, with the magnitude dependent on future emissions. At the highest emission

Figure 3: Atmospheric Concentrations of Greenhouse Gases[30]



ppb=parts per billion; radiative forcing=A measure of the change in the balance between radiation entering into the atmosphere and radiation leaving it. An increase in radiative forcing indicates that more radiation is retained within the earth's atmosphere, thus contributing to global warming.

Global Warming Pollutants

Human activities result in the release of many pollutants that are capable of altering the global climate. The main pollutants that contribute to global warming are the following:

- Carbon dioxide – Carbon dioxide is released mainly through the combustion of fossil fuels. Carbon dioxide emissions are the leading contributor to global warming and the leading global warming pollutant released in the United States. In 2004, carbon dioxide emissions represented approximately 84 percent of the U.S.'s annual contribution to global warming.[31]
- Methane – Methane gas escapes from garbage landfills, is released during the extraction of fossil fuels, and is emitted by livestock and some agricultural practices. Methane represents about 9 percent of U.S. global warming emissions.
- Nitrous Oxide – Nitrous oxide is released in automobile exhaust, through the use of nitrogen fertilizers, and from human and animal waste. It is responsible for about 5 percent of the U.S. contribution to global warming.
- Halocarbons – Used in refrigeration, air conditioning and other products, many halocarbons are also global warming pollutants. Halocarbons are responsible for about 2 percent of the U.S. contribution to global warming.[32]
- Sulfur Hexafluoride – Sulfur hexafluoride is mainly used as an insulator for electrical transmission and distribution equipment. It is an extremely powerful global warming gas, with more than 20,000 times the heat-trapping potential of carbon dioxide. It is released only in very small quantities and is responsible for only a very small portion of the nation's global warming emissions, but there are cost-effective alternatives for controlling existing emissions.
- Black Carbon – Black carbon is a product of the burning of fossil fuels, particularly coal and diesel fuel. Recent research has suggested that, because black carbon absorbs sunlight, it may be a major contributor to global warming, perhaps second in importance only to carbon dioxide. Research is continuing on the degree to which black carbon emissions contribute to global warming, and it is difficult to judge exactly how large a role black carbon might play in the United States' contribution to global warming.[33]

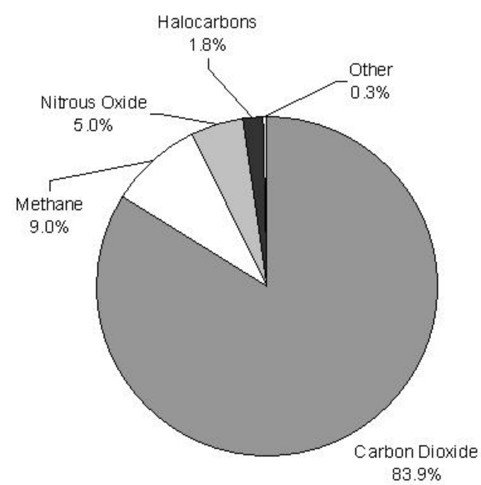
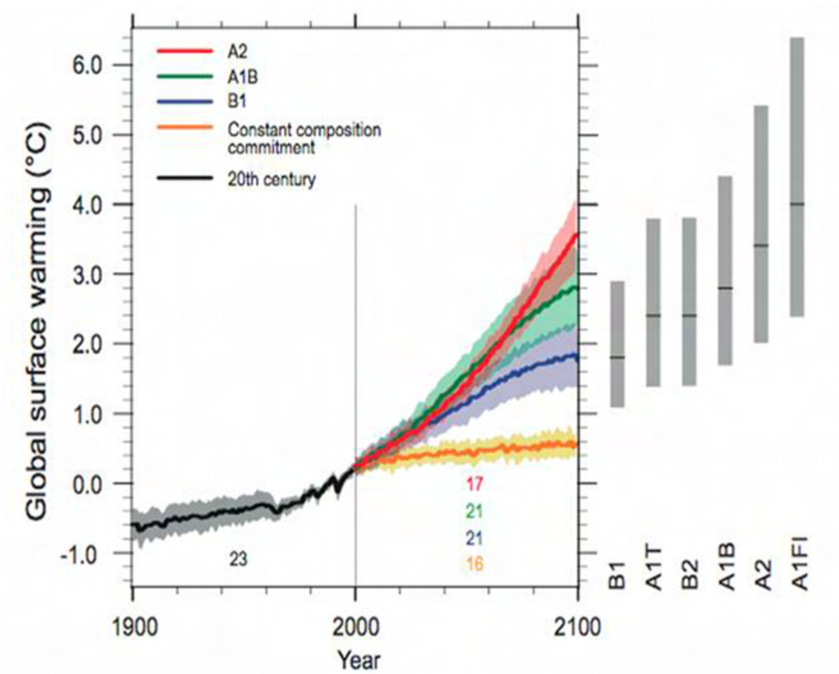


Figure 4. U.S. Global Warming Emissions by Pollutant (carbon dioxide equivalent)[34]

scenario evaluated, sea level rise could be between 10 and 23 inches. These estimates of sea level rise do not include the potential for accelerated breakup of the Greenland or Antarctic ice sheets, which would cause a more dramatic rise in sea level.[36] Scientists now consider this issue "more uncertain and possibly more serious than before."[37] For example, recent observations indicate that "the climate system, in particular sea level, may be responding more quickly to climate change" than predicted.[38] Based on the current trend of ice instability in Greenland, ocean levels could increase by as much as 20 to 55 inches over the next century.[39]

- Snow and ice cover will continue to contract, heat waves will become more frequent and severe, and hurricanes will likely become stronger.

Figure 5. Projected Temperature Increases Under a Variety of Future Emissions Scenarios*



* Intergovernmental Panel on Climate Change, Climate Change 2007: *The Physical Science Basis: Summary for Policymakers*, February 2007. Nominal temperature increases in this graphic reflect increases versus a 1980-1999 baseline and do not include increases caused by global warming prior to that period. The IPCC projects future global warming impacts based on a series of scenarios for future global development. The projections in the chart above reflect the following scenarios: "Year 2000 Constant Concentrations" assumes that concentrations of global warming pollutants in the atmosphere remain constant at 2000 levels over time. This scenario assumes that emissions are reduced dramatically and immediately, and is a very unlikely scenario for future emission trends. The remaining scenarios assume different paths for global development and global warming emissions. The scenarios assume roughly these levels of global warming pollutant concentrations in the atmosphere (in carbon dioxide equivalent): B1, 600 parts per million (ppm); A1T, 700 ppm; B2, 800 ppm; A1B, 850 ppm; A2, 1250 ppm; A1F1, 1550 ppm. By contrast, pre-industrial concentrations of carbon dioxide are estimated at approximately 280 ppm and current concentrations are at approximately 379 ppm. The gray error bars to the right of the graph indicate the range of estimates of future temperature increases, with the horizontal line in the center of each bar indicating the "best estimate" of future increase in global average temperature.

Notably, the conclusions of the IPCC, because they represent the consensus opinion of thousands of scientists and hundreds of governments, can be considered conservative. For example, some recent research suggests that positive warming feedback loops could have a greater effect—increasing temperatures by as much as 14° F by 2100, under a worst-case scenario.[40]

Maryland Impacts

Maryland is vulnerable to the impacts of global warming, in part due to its coastal location and low elevation and in part due to its large urbanized (and suburbanized) areas.

Maryland's climate is expected to grow warmer, with spring temperatures rising by 1° F to 7° F by 2100.[41] Other seasons would be warmer, with average temperatures 2 to 9° F higher. Precipitation is projected to increase by an average of 20 percent. The increase would be concentrated in the winter and would likely result in more extremely wet or snowy days.

Rising Sea Level

By 2100, sea level is expected to be another 19 inches higher.[42] Statewide, an estimated 380,000 acres of land are less than five feet above sea level and are vulnerable to complete submersion or to inundation during high tides.[43] Wicomico, Somerset and Dorchester counties are most at risk. By one estimate, shorelines in those counties could migrate inland by three to six miles.[44] In Baltimore, city officials estimate that rising sea level could trigger flooding in as many as 860 buildings, causing $420 million in damage.[45]

As sea level rises, beaches and wetlands are the first areas to be claimed by the ocean. Along undeveloped shoreline, wetlands migrate inland and new beaches form. In Maryland, however, development prevents this regeneration. Much land along the bay and ocean has been developed, leaving no room for new wetlands and beaches and causing the state to lose valuable wildlife habitat and recreation areas. Development just inland from current wetlands and beaches often is protected by storm walls, preventing the evolution of new coastal wetlands through the inundation of low-lying land. From 1978 to 1998, Maryland landowners constructed more than 300 miles of seawalls and other barriers against rising ocean waters, meaning that wetlands on the ocean side of those barriers will not be able to migrate inland.[46]

Before the ocean overtakes coastal land, salt water seeps into the freshwater below it, penetrating aquifers and drinking-water wells. Water no longer can be used for drinking or irrigating. Rising water levels can also impair the function of septic systems, making it difficult to sell affected homes.[47]

Declining Water Quality

Global warming may trigger a decline in water quality in the Chesapeake Bay, harming fish and crab populations. Increased precipitation in the bay's watershed during some times of the year will boost stream flows and the amount of nutrients that run off into the bay. Excess nutrients promote algal blooms, which can deplete oxygen levels below those needed by aquatic animals. Already, nutrient pollution causes algal blooms and areas of oxygen depletion covering more than one-third of the bay each summer.[48] The problem will grow worse as water temperatures rise, because warmer water cannot retain oxygen as easily.

Warming may cause the bay to be more or less salty. If water is saltier due to higher ocean levels, oyster diseases may spread more readily. However, too much fresh water from increased river and stream flows can kill oysters.[49]

The Loss of Plant and Animal Species

Higher temperatures and changes in precipitation will alter the mix of plants and animals that can survive in Maryland. Forested areas may shrink or become less dense. Hardwood trees could migrate north and be replaced by southern pines and oaks. Insect populations may thrive as temperatures increase.

As plant types change, birds and other animals may have to move northward to find suitable habitat. By one estimate, 34 species of birds that currently spend at least part of the year in Maryland may be forced out of the state by a changing climate, including the Baltimore Oriole, the state bird.[50]

The loss of wetlands and declining water quality in the Chesapeake Bay will harm waterfowl. Wetlands provide habitat for resident, migrating and wintering birds, such as Northern pintail ducks, osprey, snowy egrets, and redhead ducks, and the loss of wetlands to rising sea levels may cause a decline in bird populations.[51] Food supplies may dwindle as algae blooms block light and impair the growth of the aquatic plants that are an important food source for many waterfowl.[52]

Changing plant and animal populations will have an economic impact on the state. In 2001, people who hunted, fished, or watched wildlife in Maryland spent $1.7 billion in the state's economy, supporting nearly 25,000 jobs.[53] A less diverse mix of species may decrease the state's attractiveness as a destination for people seeking an outdoor experience.

Threats to Public Health

Higher temperatures will increase weather-related illnesses and fatalities. The number of heat-related deaths in Maryland could increase by 50 percent during summer heat waves.[54] Air quality could decline as hot summer days facilitate the formation of smog—ground-level pollution that can inflict respiratory damage. Smog levels in Maryland are already high enough to cause health problems and could increase further as temperatures rise.[55]

Virtually all climate predictions indicate that warming will be accompanied by an increase in climate variability. This will make for more frequent and severe summertime heat waves.[56] The severe heat wave that struck Western Europe in 2003, causing more than 35,000 heat-related deaths, may be an early example of a heat wave induced by global warming. Such events are projected to become more common by the end of the century and will have significant health impacts in cities.[57]

Table 1. Counties at High Risk of Weather-Related Problems That Could Be Made Worse by Global Warming[60]

Hazard	Counties at High Risk
Drought	Frederick, Montgomery, Howard, Carroll, Baltimore City and County, Harford, Cecil
Extreme Heat	Baltimore City
Flash/River Flooding	Frederick, Allegany
Thunderstorm	Frederick, Montgomery, Anne Arundel
Tornado	Frederick, Anne Arundel
Winter Weather	Garrett
Tidal/Coastal Flooding	Dorchester, Worcester
Tropical Cyclone	Somerset, Worcester

The incidence of insect-borne disease may rise also, as mosquito and tick populations thrive in warm, wet weather.[58] Mosquitoes in Maryland have already been found to carry West Nile virus, malaria, dengue fever and St. Louis encephalitis. Ticks may transmit Lyme disease.

Declining Agricultural Production

Higher temperatures and increased precipitation would affect Maryland's $1.3 billion agricultural industry. The state's primary crops are corn, hay, soybeans and wheat. Higher temperatures would decrease corn and hay production, while soybean and wheat production could rise or fall, depending on precipitation changes.[59]

The precise effects of global warming will be unpredictable and may be sudden. Rising sea levels may gradually erode shoreline for years, or a hurricane aimed straight up the bay may create an unprecedented storm surge that destroys land and property not typically considered at risk. An unusually dry and hot year could wreak havoc on the state's drinking water supplies and force the development of expensive alternatives. In other words, the impacts of global warming will include severe and unforeseen events, not merely a gradual change in current conditions.

The Need for Immediate Action

There is hope in the climate science, however. Scientists tell us that, if we act quickly and aggressively to reduce global warming emissions, there is a much greater chance of staving off the worst impacts of global warming. To have a reasonable chance of keeping global temperatures from rising by more than 2.0° C, the atmospheric concentration of carbon dioxide must not rise above 450 parts per million (ppm)—about 60 percent higher than pre-industrial levels and about 18 percent higher than today.[61]

To stabilize carbon dioxide levels at 450 ppm, however, the world will need to halt the growth of global warming pollution and begin reducing emissions by 2020 at the latest, and slash emissions by more than half by 2050.[62] Because the U.S. is the world's largest global warming polluter, the degree of emission reductions required here will be greater than in less-developed countries—as much as 80 percent below today's levels.

By adopting an aggressive target for reducing global warming pollution and setting in motion the changes that will meet that target, Maryland can reduce its significant contribution to global warming.

Global Warming Pollution in Maryland

Maryland is a significant contributor to global warming, mainly through the release of carbon dioxide resulting from consumption of fossil fuels. In 2004, the last year for which complete data are available, the use of energy in Maryland was responsible for the release of approximately 81.8 million metric tons of carbon dioxide, the leading global warming pollutant.[63] Were Maryland its own country, it would have ranked 41st in the world for emissions during 2004, ahead of nations such as Sweden and Austria.[64]

Maryland's emissions of carbon dioxide have been increasing and are likely to increase still further in the years to come in the absence of concerted action to reduce global warming pollution. Various sectors of Maryland's economy are responsible for varying amounts of global warming pollution and will require different strategies to reduce emissions.

Global Warming Pollution on the Rise

Between 1990 and 2004, carbon dioxide emissions from energy use in Maryland increased by 11.1 $MMTCO_2$—or about 16

Counting Global Warming Pollution: Background on this Analysis

There are many ways to calculate a state's impact on the global climate. Estimates of global warming pollution and pollution trends depend on the original data source used and the types of emissions that are included or left out.

In this document, we use energy consumption data and projected regional trends compiled by the U.S. Energy Information Administration (EIA) as the basis of our estimates of Maryland's past, current and future carbon dioxide emissions (called the "reference case" in this report). The methods we used to project future emissions are described in detail in the "Methodology" section at the end of this report.

This report includes only energy-related emissions of carbon dioxide and not emissions of other global warming pollutants (like methane and nitrous oxide). In addition, our estimates are calculated on a production basis—that is, based on emissions that take place within Maryland's borders. An alternative approach would be to calculate emissions on a consumption basis, including all emissions resulting from the consumption of energy or products within Maryland, regardless of where the actual emissions take place. This distinction is especially important with regard to the electricity sector, since Maryland is a net importer of electricity from other states. Our estimates only include emissions from electricity that is generated within Maryland's borders, and not emissions from power plants in other states that generate electricity for use in Maryland.

Because we calculate emissions on a production basis, we also generally do not include "upstream" emission reductions (for example, from reduced production of gasoline in other states due to reduced demand from vehicles in Maryland) in our estimates of pollution savings from the various strategies discussed in this report. As a result, many of the strategies discussed will deliver greater overall emission reductions than are estimated here.

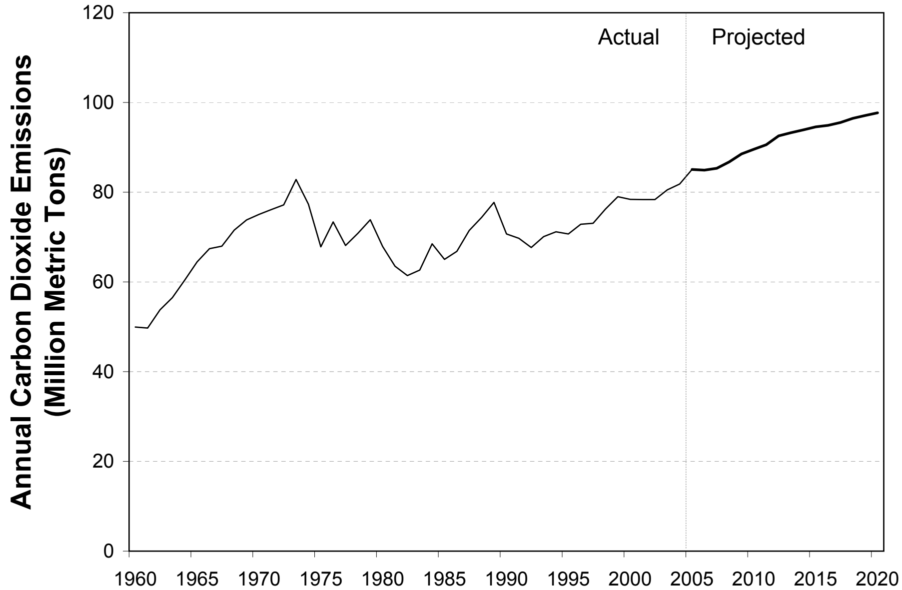
Finally, there are multiple ways of expressing quantities of global warming emissions. We have chosen to express emissions in terms of million metric tons of carbon dioxide (or $MMTCO_2$). Some other studies use million metric tons of carbon or carbon equivalent (MMTCE) as the unit of measure. To convert carbon equivalent to carbon dioxide, one can simply multiply by 3.67.

percent—a rate of increase lower than the U.S. as a whole, which saw carbon dioxide emissions increase by 18 percent during that same period.[65]

Maryland's emissions of carbon dioxide are expected to rise over the next 15 years. In the absence of measures to reduce global warming pollution (including several measures Maryland has already committed to implement), the state's carbon dioxide emissions could be expected to increase by 19 percent over 2004 levels by 2020. (See Figure 6.)

Over the next 15 years, Maryland's emissions from all sectors can be expected to increase, with the greatest increase taking place in the transportation sector. Emissions in the transportation sector are

Figure 6. Projected Carbon Dioxide Emissions, Reference Case

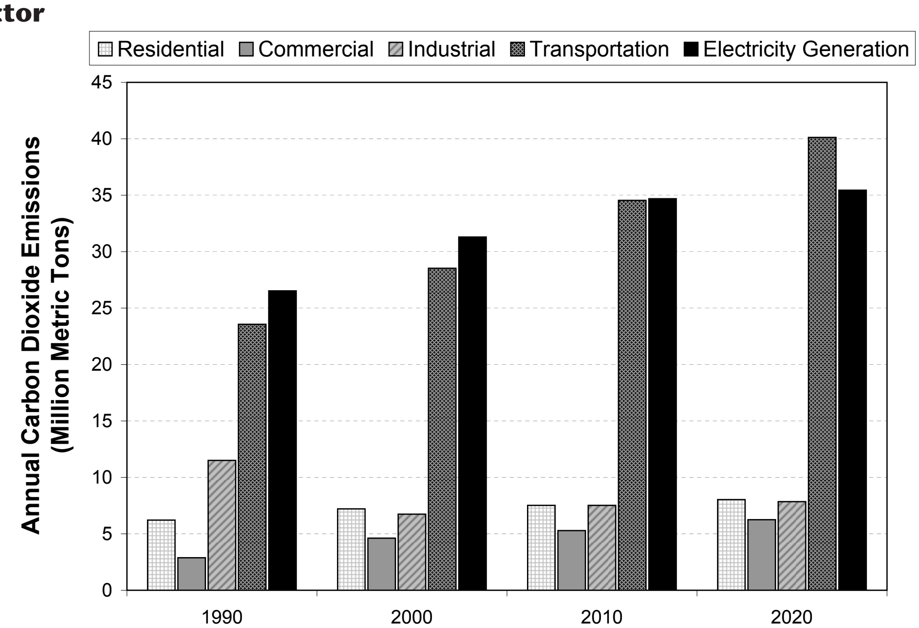


projected to increase by 9.2 $MMTCO_2$ (30 percent) from 2004 to 2020. Carbon dioxide pollution from electricity generation can be expected to increase by 4.3 $MMTCO_2$ (14 percent), with smaller gross increases in emissions resulting from direct use of fossil fuels in the commercial (1.3 $MMTCO_2$ or 25 percent), residential (0.91 $MMTCO_2$ or 13 percent) and industrial (0.27 $MMTCO_2$ or 4 percent) sectors. (See Figure 7.)

Sources of Carbon Dioxide Emissions in Maryland

A coherent strategy to address global warming pollution in Maryland must be-

Figure 7. Historic and Projected Maryland Carbon Dioxide Emissions by Sector



gin from an understanding of the sources of the pollution. Electricity generation is the leading source of global warming emissions in Maryland, but emissions from transportation are likely to increase so much over the next 15 years that it could become the largest source of emissions. Pollution from all sectors of the economy is projected to increase to varying degrees over the coming years.

Electricity Generation

Power plants are the largest source of carbon dioxide emissions in Maryland, responsible for about 38 percent of the state's emissions. Adding in emissions from out-of-state power plants that supply electricity to Maryland would increase the climate impact of electricity consumption in Maryland by more than 20 percent. Emissions from electricity generators in Maryland increased by 17 percent between 1990 and 2004.

The vast majority of global warming emissions from electric generation in Maryland come from coal and natural gas-fired power plants. (Maryland's nuclear power plant, which generates slightly more than one quarter of the power produced in the state, produces no direct carbon dioxide emissions, but does have significant environmental and public safety impacts. See "Nuclear Power in Maryland," page 27.) Maryland's coal-fired power plants produce nearly 90 percent of carbon dioxide emissions from power generation in Maryland, despite the fact that those plants produce only slightly more than half of the power generated in the state.

Transportation

Maryland's second largest source of carbon dioxide emissions is the transportation sector. In 2004, transportation accounted for 38 percent of the state's energy-related carbon dioxide emissions. Between 1990 and 2004, global warming pollution from transportation increased by 31 percent.

Personal vehicles such as cars, pick-up trucks and SUVs are the main sources of global warming pollution in Maryland, accounting for three-quarters of the state's transportation-related emissions.[66] The number of miles traveled on Maryland's highways increased by 36 percent from 1990 to 2004, to 55 billion miles per year.[67] Population growth accounts for some of the increase, but the number of vehicle-miles traveled per capita also increased by 17 percent between 1990 and 2004.[68]

Maryland's highways are also major corridors for the shipment of freight along the East Coast, resulting in significant emissions from heavy trucks.

By 2020, global warming pollution from gasoline consumption in Maryland (most of it used in cars and light trucks) is expected to increase by approximately 27 percent, while consumption of diesel fuel (used primarily in heavy-duty trucks and trains) is poised to increase by 42 percent. Reducing global warming emissions from Maryland's transportation sector, therefore, will require action on a number of fronts, with efforts to reduce emissions from personal vehicle travel the most pressing, but action on freight emissions required as well.

Residential, Commercial and Industrial Energy Use

Industrial energy consumption (not counting electricity use) accounted for 9 percent of Maryland's carbon dioxide emissions in 2004. Carbon dioxide emissions from industrial energy use declined by 35 percent between 1990 and 2004 as the state lost significant amounts of industrial capacity and as Maryland industries improved their energy efficiency. In contrast, electricity consumption increased, with Maryland industry consuming 10 percent more electricity in 2004 than it did in 1990. Carbon dioxide emissions from industry are expected to increase only modestly over the next 13 years.

Direct consumption of fossil fuels in Maryland homes (not including electricity consumption) accounted for about 9 percent of the state's carbon dioxide emissions in 2004. Consumption of natural gas for home heating rose by 29 percent from 1990 to 2004, a rate of increase much greater than the state's 17 percent increase in population.[69] Household consumption of electricity increased by 46 percent, part of the reason that carbon dioxide emissions from electricity generation increased over that period.

Direct fossil fuel consumption in commercial buildings accounts for the remaining 6 percent of Maryland's carbon dioxide emissions. Carbon dioxide pollution from commercial buildings increased by 73 percent between 1990 and 2004, driven largely by a near-tripling of natural gas use. Electricity consumption also increased, rising 57 percent in commercial buildings over that time period, helping to fuel the increase in global warming emissions from electricity generators since 1990.

Addressing Global Warming Pollution in Maryland

Maryland must address global warming emissions from all sectors of the state's economy. Fortunately, there are many policy options that have the potential to curb global warming emissions in the state while boosting Maryland's energy security and the long-term health of its economy. The policy suggestions that follow are not the only options available to the state, nor are they likely to be sufficient to reduce Maryland's global warming emissions to levels consistent with preserving the global climate. But they do have the potential to reverse the trend toward rising global warming emissions in the state within the next decade and to put Maryland on a trajectory toward further reductions in global warming pollution in the years to come.

Global Warming Strategies for Maryland

Commitments Already Made

Maryland has already taken action to head off future increases in global warming pollution. Over the past several years, the state has adopted several major measures—a cap on carbon dioxide emissions from power plants, stronger vehicle emission standards, a renewable electricity standard, and stronger appliance efficiency standards—that, if fully implemented, will begin to reduce carbon dioxide emissions in the state. The ultimate success of these measures, however, is not a given. Maryland has much work to do to ensure that the state's policy initiatives on global warming deliver real results.

Regional Greenhouse Gas Initiative

Maryland recently joined with nine other northeastern and mid-Atlantic states to create the first regional "cap and trade" program for global warming emissions in the United States. Known as the Regional Greenhouse Gas Initiative (RGGI), the program will cap and then reduce emissions from electricity generators in the northeast and mid-Atlantic. Should the program be designed in such a way as to force emission reductions at electric power plants in Maryland, the state could see reductions of as much as 4.6 $MMTCO_2$ versus reference case projections by 2020.

Under RGGI, electricity generators will be required, starting in 2009, to hold permits (called "allowances") for each unit of carbon dioxide pollution they release to the environment. The number of allowances is fixed. If a company wishes to emit more pollution, it must buy additional allowances from companies that have succeeded in cutting their emissions.

In 2009, the number of allowances issued annually to Maryland power plants will be capped at 34.1 $MMTCO_2$ (or 37.5 million short tons of CO_2). The same number of allowances will be available each year through 2014. Between 2015 and 2019, the number of allowances issued will be reduced by 2.5 percent per year, such that emissions in 2019 are 10 percent below 2009 levels.[70]

Given that emissions from electricity generation in Maryland are projected to increase significantly over the next two decades, achieving the RGGI target would represent a significant reduction in global warming emissions versus business-as-usual levels. However, the RGGI agreement and the draft model rule that has been developed to implement the program include a number of potential loopholes that could reduce the program's effectiveness in achieving its goals:

- Leakage: RGGI will only help reduce global warming pollution if it creates emission reductions in the aggregate and does not simply result in the transfer of emissions from RGGI states to power plants in states not covered by the program. Unfortunately, the RGGI rules, as currently written, do nothing to address "leakage" of emissions from Maryland or other RGGI states to states not participating in the program. To address the problem of leakage, power imports must be included in the RGGI structure.

- Offsets: "Offsets" are emission reductions or carbon capture projects that take place at facilities that aren't covered by RGGI, but which can be used by RGGI participants to lessen the emission reductions they must make at their power plants. In theory, offsets allow companies covered by the program to achieve similar pollution reductions at lower cost if they can be had more cheaply elsewhere. In practice, however, offsets pose difficult enforcement challenges.[71] The RGGI program, as currently proposed, allows companies to cover up to 3.3 percent of their emissions with offsets. However, the program would also allow greater use of offsets if the price of an emission allowance exceeds $7/ton.

  These provisions could allow for Maryland power plants to maintain higher emissions than their RGGI target would otherwise allow, without sufficient guarantees that those higher emissions are matched by emission reductions elsewhere.

Maryland deserves credit for having joined the RGGI program. The program includes some cutting-edge elements, such as requiring the auctioning of some carbon dioxide allowances for public purposes (and giving states the option to auction 100 percent of the allowances), with revenues from the sale of the allowances used to support energy efficiency or renewable energy programs or to defray some of the costs of the program for consumers.

Maryland should commit to auctioning all of its allowances, as New York, Massachusetts, Maine and Vermont have already pledged to do. Selling the allowances to electricity generators will help fund energy efficiency and renewable energy programs that will offset the cost of complying with RGGI. It would also prevent power plant owners from gaining unjustified windfall profits at the expense of consumers.

In addition, the state should use its position in the RGGI process to advocate for the closing of loopholes that would erode the carbon cap. By doing so, it can guarantee that the emission reductions promised by RGGI (and assumed in this analysis) will be achieved.

Policies discussed later in this report that reduce electricity consumption in Maryland will likely make it easier and cheaper for the state to meet its RGGI targets. They won't, however, cause an overall reduction in emissions, since cuts in pollution in Maryland could be offset by increases in emissions in other RGGI states.

The analysis in this report shows that Maryland can reduce emissions far beyond the targets set for the state under RGGI. To fully realize these reductions, however, the state will need to work with other RGGI states to reduce the overall emission cap in the years to come. This analysis assumes that Maryland can realize all the benefits of energy efficiency and renewable energy, including those that are above and beyond the RGGI targets.

Clean Cars Program

In 2007, the Maryland General Assembly adopted and Governor O'Malley signed the Clean Cars Act, which commits the state to adopting stronger standards for automobile air pollution—including global warming pollution. The Clean Cars Program's global warming component alone will reduce global warming pollution by about 3.5 $MMTCO_2$ by 2020, or by about 3.6 percent versus projected statewide emissions.

The federal Clean Air Act allows states that fail to meet clean air health standards to choose between two sets of emission standards: those in place at the federal level and the traditionally tougher standards adopted by the state of California, known as the Clean Cars Program. One key element of

Nuclear Power in Maryland

About 28 percent of the electricity generated in Maryland comes from the state's two nuclear reactors—Calvert Cliffs I and II.[72] First licensed for operation in the mid-1970s, the two plants have received approval from the Nuclear Regulatory Commission to continue operating until the mid-2030s.[73] Constellation Energy, which owns and operates the plants, has indicated a desire to expand the nuclear facility by constructing a third unit.

However, nuclear power poses a variety of public safety and environmental problems. The facility should not be expanded and the existing units should be retired at the end of their extended operating licenses, if not sooner.

Nuclear waste and terrorism: The two reactors at Calvert Cliffs consume 44 tons of uranium annually, producing 17,000 spent fuel rods that must be disposed of. However, in the absence of a national repository for nuclear waste, the spent nuclear fuel is stored in and near the plant, providing a potential target for terrorists and creating a safety threat. The waste materials produced by nuclear power are also of potential interest to terrorists. Some of Calvert Cliffs' waste is stored in a water-filled pool between the two reactors. Additional waste is kept in casks next to the plant.[74]

Cooling water and fish kills: The Calvert Cliffs reactors are cooled by large amounts of water drawn from the bay. An estimated 100,000 small fish are killed annually when they are trapped on the screens filtering the water that enters the plant.[75] The water is discharged at elevated temperatures back into the Chesapeake Bay. This change in temperature harms aquatic life.

The energy efficiency and renewable energy policies described in this report not only help Maryland to reduce its contribution to global warming, but can help reduce the state's dependence on its aging nuclear power plant.

By moving forward with a clean energy policy that emphasizes renewable energy development and improved energy efficiency, Maryland can meet its electricity needs without extending the lifetimes of its nuclear power plants and without adding new fossil fuel-fired generation that contributes to global warming.

the program is tailpipe emission standards for global warming pollution.

A 2002 expansion of the Clean Cars Program required the California Air Resources Board (CARB) to propose limits that "achieve the maximum feasible and cost effective reductions of greenhouse gas emissions from motor vehicles." Limits on vehicle travel, new gasoline or vehicle taxes, or limitations on ownership of SUVs or other light trucks could not be imposed to attain the new standards.[76]

In September 2004, CARB adopted fleet average standards for global warming pollution that will reduce emissions from new cars by approximately 34 percent and emissions from new light trucks by 25 percent by 2016.[77] CARB estimates that adoption of the standards would lead to net consumer benefits of $3 per month for new car purchasers and $7 per month for light-truck buyers, with the higher cost of vehicles being more than offset by reductions in operating costs, primarily the cost of fuel.[78] The financial benefits are likely to be even greater now, due to higher gasoline prices.

The Clean Cars Program also includes a requirement that automobile manufacturers supply increasing quantities of "advanced technology" vehicles such as ultra-clean gasoline-powered cars and trucks, hybrid-electric vehicles, and eventually hydrogen fuel-cell vehicles. Many of these technologies have the potential to reduce global warming emissions dramatically in the decades to come.

In 2006, California adopted a new law capping all global warming emissions at 1990 levels by 2020, which translates into a 25 percent reduction in emissions from current levels.[79] The new law could lead California to pursue tighter limits on global warming emissions from vehicles beyond 2016.

Maryland should fully implement the Clean Cars Program and work to defend the program against legal or political attacks from automakers and other powerful interests.

Renewable Electricity Standard

In 2004, Maryland adopted a renewable electricity standard (RES) that will require a gradual increase in the amount of renewable energy supplied to Maryland electricity consumers. Beginning in 2006, 1 percent of the power sold in the state came from clean renewable sources. The target level increases every other year. The law was amended in 2007 to increase the total amount of electricity that must be generated from renewable sources. By 2022, 9.5 percent of Maryland's electricity must come from clean renewable power.[80] Eligible sources of electricity include wind, solar, geothermal, some biomass, methane from landfills or wastewater treatment plants, wave energy, and small hydropower. To spur the development of solar power, the law includes a requirement that an increasing amount of energy come from solar, reaching 2 percent of total electricity sales in Maryland in 2022.

As discussed later, Maryland's standard should be improved. For example, New Jersey recently adopted an RES that will require 20 percent of electricity to come from renewable sources by 2020.[81] Additionally, Maryland should tighten the list of sources that qualify as renewable energy. In particular, the state should exclude existing hydropower capacity. Further, to minimize power losses during transmission and to bring as many of the air pollution benefits of renewable energy as possible to Maryland, the RES should be modified to include power generated within the PJM Interconnection only and not adjacent grids.

Enough renewable electricity generation is incorporated into the reference case emission figures to cover the requirements of the original 2004 renewable electricity standard. Emission reductions from the 2007 amendment that increases the requirement will save an estimated 0.8 $MMTCO_2$ versus the reference case in 2020.

Appliance Efficiency Standards

Many appliances that Maryland homeowners and businesses use can be made significantly more energy efficient than they are today. Maryland has adopted energy efficiency standards for a range of residential and commercial appliances that will save Maryland consumers money and reduce the state's consumption of energy.

In 2004, Maryland helped pave the way for stronger national appliance efficiency standards by adopting standards for a variety of household and commercial appliances, including torchiere lamps, exit signs, traffic signals and commercial air conditioners. The adoption of state standards by Maryland and other states led the U.S. Congress to include federal energy efficiency standards for 15 new appliances in the 2005 Energy Policy Act.

In 2007, Maryland adopted standards for residential furnaces in new construction, commercial hot food holding cabinets, walk-in refrigerators and freezers, incandescent reflector lamps, liquid immersed distribution transformers, metal halide lamp fixtures, external power supplies for consumer electronics, and bottle-type water dispensers.[82]

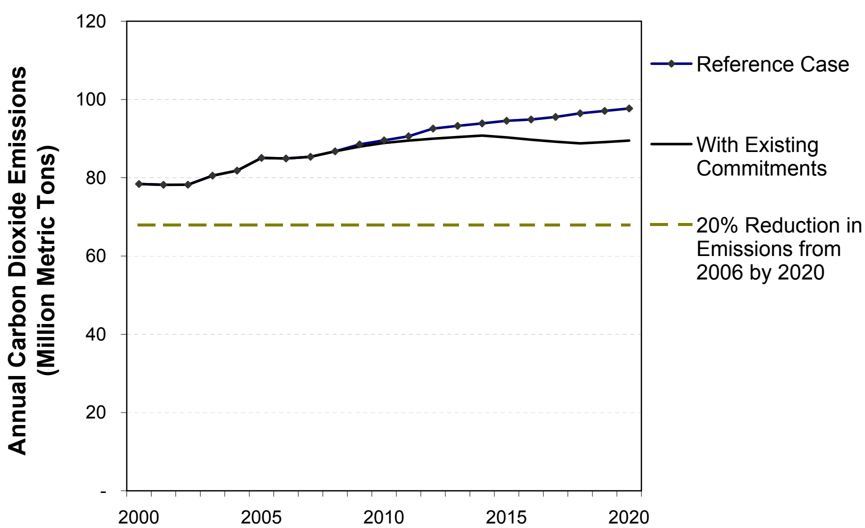
These standards will reduce global warming pollution by 0.4 $MMTCO_2$ in 2020. The American Council for an Energy Efficient Economy (ACEEE) and the Appliance Standards Awareness Project (ASAP) further estimate that these standards will reduce electricity demand by 880 gigawatt-hours (GWh) in 2020, reduce natural gas demand by 290 million cubic feet, and save Maryland more than $884 million over time.[83]

The benefits of appliance efficiency standards could be increased if the state also adopted stronger standards for boilers, for replacement furnaces in existing buildings, for DVD players and recorders, and for compact audio products.

Total Impact of Commitments Already Made

The policies that Maryland has already adopted and that are not already included in the baseline emissions estimate—the Clean Cars Program, the Regional Greenhouse Gas Initiative, the 2007 amendments to the renewable electricity standard, and more appliance efficiency standards—will reduce Maryland's emissions by 8.2 $MMTCO_2$ versus the reference case in 2020.

Figure 8. Emission Reductions from Existing Commitments



Strategies for Further Reducing Global Warming Emissions

The policies that Maryland has already adopted to reduce carbon dioxide emissions will help the state begin to curb growth in global warming pollution. But they are not nearly enough. The state still faces major challenges in ensuring that its policy initiatives deliver results. And Maryland must find additional strategies to achieve the reductions in carbon dioxide pollution that will be necessary to reduce the threat of global warming.

Maryland has many strategies that it can pursue to reduce global warming emissions. The following nine strategies, listed in order of their impact, are among those the state can use to improve the energy efficiency of its economy and significantly reduce global warming emissions.

Strengthen the Renewable Electricity Standard

Potential Savings: 4.8 million metric tons of CO_2 by 2020.

In 2004, Maryland adopted a renewable electricity portfolio standard (RES) that requires that a portion of the power delivered by utilities to the state's customers be from renewable energy sources. As discussed above, the percentage of renewable power increases over time, providing a scheduled ramp-up to the provision of 9.5 percent of the state's electricity from renewable sources in 2022.

The state should increase the rate at which the requirement rises, so that the state receives 20 percent of its power from clean, renewable sources by 2020. This would allow Maryland to achieve savings of 4.8 $MMTCO_2$ in 2020. Achieving this level of renewable energy production is entirely feasible using power generated in Maryland and neighboring states.

Maryland's on-shore wind energy potential is estimated to be as high as 5.6 million megawatt-hours (MWh) annually, 8 percent of Maryland's annual electricity consumption of 68 million MWh.[84] Off-shore, the National Renewable Energy Laboratory estimates the state could generate 5.2 to 66.5 million MWh.[85]

Maryland has the potential to generate more than 2 million MWh of electricity using biomass products such as forest and agricultural residue and dedicated energy crops.[86] Other clean biomass energy technologies, such as anaerobic digesters and generators at landfills and wastewater treatment plants, represent additional generating potential.

Solar energy is another option. Baltimore, for example, receives enough solar radiation that a 377 square foot solar module can produce 4,900 kWh of electricity per year.[87] Installing a solar panel of this size on the roof of a home would yield one-third of a household's annual electricity needs, with periods of highest generation on hot summer days coinciding with periods of greatest demand for air conditioning.[88] Solar panels on homes across the state could dramatically boost renewable energy generation. The National Renewable Energy Laboratory estimates that total statewide solar generation could be as high as 16.6 million MWh.[89] This is equal to 24 percent of Maryland's current annual electricity consumption. (See "Investing in Solar Power.")

Using a mix of on- and off-shore wind power, solar and biomass resources would allow Maryland to generate 20 percent of its energy from renewable sources within the state.

However, Maryland does not necessarily need to be able to get all of its renewable power from sources located in the state. It could import renewable energy from neighboring states. Maryland is part of a regional electricity grid that includes Delaware, New Jersey, Pennsylvania, Virginia and West Virginia and already imports electricity from those states.

Investing in Solar Power

Solar energy represents one of the best long-term hopes for Maryland to slash its consumption of fossil fuels and emissions of carbon dioxide. By supporting the development of solar energy now, Maryland can be in a better position to fully reap the benefits in the decades ahead.

Solar energy is currently a small player in the generation of electricity in Maryland and around the country. However, solar thermal technologies and solar photovoltaics (PV) have the potential to make a major contribution to a clean energy future. Solar PV costs have gone down by 75 percent over the past 20 years.[92] The BP Solar manufacturing plant in Frederick is planning an expansion that will make it the largest integrated solar manufacturing facility in the U.S. With its solar manufacturing capacity, Maryland can play a leading role in positioning solar power to make a major contribution to the state energy system.[93]

Solar Thermal Energy and Passive Solar

Using the sun's rays to generate electricity is just one of many ways to use solar energy to reduce the use of fossil fuels and cut global warming emissions. Solar water heating systems use solar energy to produce hot water for bathing, laundry and other household uses. Installation of a rooftop solar water heating system can reduce energy consumption for water heating by about two-thirds.[94]

Solar energy can also be used to heat and cool buildings. Passive solar building design uses appropriate building layouts and the judicious use of glass to light and heat interior building spaces.

Many solar water heating systems and passive solar designs have the advantage of being less expensive to implement (and often more cost-effective) than solar PV systems. Maryland's tax credit for up to 20 percent of the cost of installing a solar water heating system is a step toward promoting solar energy. Incentives or standards for energy-efficient buildings could encourage the development of buildings that use passive solar heat and light.

Solar water heating systems and passive solar energy have great potential to reduce fossil fuel consumption in Maryland.

Solar Photovoltaics

The state recently expanded its renewable electricity standard to include a requirement that a percentage of energy come from solar PV. By 2022, 2 percent of the electricity sold in Maryland must come from solar energy.[95] In addition, companies that install a solar PV array can sell renewable energy credits to an electric utility, providing immediate funding to help pay for the solar PV installation and allowing the utility to comply with solar generation requirements. This will mostly increase solar PV installations by commercial establishments.

Now Maryland should focus on providing incentives to stimulate the use of solar PV in residential settings. Maryland currently offers a subsidy of up to 20 percent of the cost of installing a solar PV system on a home, with a maximum credit of $3,000.[96]

(Continued, page 32)

(Continued from page 31)

However, this incentive is so small that it does little to offset the cost of a solar PV system and demand has been very low.

To promote residential use of solar PV, Maryland should:

- **Expand incentives** for each Watt of solar photovoltaic capacity that homeowners or businesses install. Maryland should offer incentives of 50 percent for both residential and small commercial customers and should increase overall funding for solar PV.

- **Incorporate solar into new home design and construction**. Maryland builds thousands of new single-family homes each year. Incorporating solar PV systems into homes during construction is one of the most cost-effective and efficient ways to build the state's solar market. Policies targeted specifically at new homes—such as requirements to install solar on an increasing percentage of new homes or simply to make systems readily available to homebuyers—can develop one of the most cost-effective parts of the residential PV market.

  Homes equipped with solar panels reduce energy bills for homeowners, potentially increasing the amount of income they can afford to spend on a mortgage and boosting their satisfaction with their home. More than half of homeowners who recently purchased a solar home did so to save money and more than 80 percent believe the solar panels will be a positive feature when reselling the home.[97]

Maryland should work toward the goal of installing solar panels on the roofs of 20 percent of new homes built by 2020. Achieving this goal would not only reduce carbon dioxide emissions, but would also enhance the stability of the state's electric system and create economies of scale that will make solar power a cost-effective alternative for Maryland homeowners and businesses within the next two decades. The state would then be poised for a dramatic increase in solar installations in subsequent years, precisely when the state will be seeking deep reductions in its global warming emissions in keeping with the long-term goal of preventing further harm to the climate.

Regional renewable energy potential is substantial. The six states' on-shore wind potential is estimated to total 77 million MWh and biomass potential is estimated at 28.5 million MWh.[90] Several states have adopted their own RES, but there is more than enough renewable energy potential in the regional power grid to satisfy a 20 percent RES for all six states. The region's on-shore wind and biomass co-firing energy potential is equal to 24 percent of regional electricity consumption of 446 million MWh.[91] Adding solar resources, off-shore wind and other biomass would increase the region's renewable electricity generating potential.

In sum, filling a 20 percent by 2020 renewable electricity standard for Maryland is possible—even without factoring in future technology improvements that could make solar panels more effective at turning the sun's energy into electricity and wind power feasible at lower wind speeds. Adding other types of renewable energy to the mix—such as landfill gas and solar PV—makes the goal of generating 20 percent of all electricity consumed in Maryland by 2020 from clean sources even more feasible.

To facilitate distributed generation, the state should also adopt a net metering law that allows consumers to sell unused power from their home-based generating capacity to the electricity company. Currently, consumers may receive credit toward their utility bill for electricity they generate, but cannot sell additional power to the electricity company.

As Maryland considers expanding its RES, it should adhere to a commitment to truly clean, truly renewable technologies. Polluting and environmentally damaging technologies, along with those that rely upon non-renewable resources, should continue to be ineligible for credit under the RES.

Adopt a Low-Carbon Fuel Standard

Potential Savings: 3.7 million metric tons of CO_2 by 2020.

Maryland can reduce its petroleum dependence while cutting global warming pollution by enacting a low-carbon fuel standard for fuels used in light-duty vehicles. A low-carbon fuel standard would require that increasing amounts of fuel sold in Maryland come from sources with lower life-cycle global warming emissions than gasoline or diesel.

Fuels with lower life-cycle carbon emissions than gasoline and diesel may include ethanol, biodiesel, electricity, and hydrogen. Biofuels are typically made from such crops as corn and soybeans. Technology that would allow cellulose from plant residues or "energy crops" (such as switchgrass) to be turned into fuel holds the promise of even greater energy and global warming pollution benefits. The carbon emissions of biofuels depend on how they are produced, including pesticide use, farming practices, processing method, and transportation to consumers. For electricity and hydrogen, life-cycle carbon emissions are most affected by the fuel used to generate power or produce hydrogen fuel.

Renewable fuels currently are mixed with petroleum-based fuels, such as gasoline or diesel. Blends with low percentages of biofuels can be used in virtually all vehicles, but this can lead to increases of some air pollutants. To run a vehicle on higher percentages of ethanol requires upgrades to the vehicle's engine and the technology for this is already well developed and in use in millions of vehicles.

Plug-in hybrid cars and hydrogen vehicles have not yet been commercialized, but automakers are demonstrating the feasibility of these technologies through small-scale trials. A low-carbon fuel standard would encourage development of less polluting fuels, the vehicles that use them, and a new fuel distribution infrastructure.

Maryland should establish a goal of reducing the carbon content of the state's gasoline and diesel fuel mix by 10 percent by 2020. The standard could be implemented beginning in 2011 with a 1 percent reduction, and increasing by 1 percent per year. This gradual implementation will allow for development of technologies to create biofuels from cellulose and construction of a distribution network.

California recently adopted a similar low-carbon fuel standard.[98] The state expects that the standard will replace 20 percent of the state's gasoline consumption with lower-carbon fuels.[99] A number of other states require the use of renewable fuels, though these standards do not directly target global warming pollution. Nonetheless, they demonstrate the feasibility of increasing the production and distribution of fuels with potentially lower global warming emissions.[100]

Ethanol may soon be produced in Maryland, meaning that less of the money that consumers spend on fuel will leave the state. Recently, the Somerset County Commission approved the construction of a facility to produce ethanol near Pocomoke City. The plant could be operational as early as spring 2008 and able to produce 50 million gallons of ethanol annually.[101]

As Maryland moves forward with a low-carbon fuel standard, it is important that the state make policy decisions that maximize the benefits of the standard and limit environmental hazards. The state should ensure that implementation of the fuel standard does not adversely affect air quality. To encourage the use of higher-percentage blends of ethanol (such as E85), the state should ensure that "flex-fuel" vehicles are able to take full advantage of their potential for using renewable fuels by encouraging construction of adequate refueling infrastructure. (See "Making Biofuels Sustainable.")

Reduce Growth in Vehicle Travel Through Smart Growth and Expanded Transportation Choices

Potential Savings: 0.9 million metric tons of CO_2 by 2010; 3.3 million metric tons of CO_2 by 2020.

The growth in vehicle-miles traveled (VMT) over the last several decades has its roots in many societal changes—rapid population growth in Maryland, low gasoline prices, expansion of the workforce, and residential and commercial suburban sprawl.

Reversing this trend will be challenging, but success would bring benefits not only in reducing global warming emissions but also in easing traffic congestion, reducing public expenditures on highways, enhancing Maryland's energy security, and reducing automotive emissions of other pollutants that harm public health. The emission reductions projected for this strategy assume that Maryland can hold per-capita vehicle-miles traveled steady over the next 13 years—in other words, that VMT would increase only at the rate of population growth. Even more aggressive reductions in vehicle travel may be possible in the future.

Stabilizing per-capita vehicle-miles traveled at today's levels would avoid a large projected increase in vehicle travel over the next 13 years. By stabilizing per-capita travel, the number of vehicle-miles traveled in Maryland would increase by about 17 percent between 2005 and 2020, compared with an approximate 34 percent increase in the reference case scenario.[105]

Maryland residents have already begun to cut back on driving as a result of higher fuel prices. Data from the Federal Highway Administration indicates that 1.9 percent fewer vehicle miles were driven on Maryland highways in March 2007 than in March 2006.[106] Baltimore-region transit ridership increased two percent in 2006 over 2005. Light-rail use rose 11 percent, MARC train ridership rose 6 percent, and commuter bus service rose 5 percent in Baltimore and 9 percent in D.C.[107]

Maryland's population is projected to increase by more than 900,000 people from 2005 to 2020, creating challenges to any effort to reduce driving but also offering opportunities for new solutions. An important element of Maryland's response to this anticipated population growth is encouraging more compact development based around access to transit. The influx of workers and residents from the Base Realignment and Closing (BRAC) process offers Maryland an additional challenge and opportunity to address development and transportation patterns.

Making Biofuels Sustainable

The biomass-based fuels that likely would be produced to meet a low-carbon fuel standard can make a significant contribution to reducing global warming pollution. However, environmental damage can result if increased production of these fuels is managed poorly.

To maximize the environmental benefits of biofuels, policies must be in place to ensure that they are developed sustainably.

- **Protect air quality** – Low concentrations of ethanol in gasoline (such as E10) can result in increased emissions of smog-forming pollutants.[102] Motor vehicle air pollution standards should be revised to ensure that the use of ethanol does not result in overall increases in urban smog. In addition, public policy should encourage the use of ethanol fuels in higher blends (such as E85), which do not pose a threat to air quality.

- **Ensure sustainable production** – The way biofuels are produced has a large impact on their ultimate environmental benefits. Some agricultural methods for producing biomass can contribute to environmental problems such as nutrient enrichment of waterways and soil erosion.[103]

  Increasing production of feedstocks for biofuels could encourage negative agricultural practices (such as broader use of genetically modified crops or applications of toxic pesticides) or the conversion of ecologically important areas to energy crops.

  A sustainable biofuels strategy must recognize these challenges and ensure that the agricultural and industrial processes used to produce biofuels do not cause unintended harm to the environment or the climate.

- **Don't substitute biofuels for efficiency improvements** – Biofuels can provide an important supplement to fossil fuels, but they are no substitute for using energy more efficiently. The "dual-fuel" loophole in U.S. automobile fuel economy standards, for example, gives automakers credit toward their fuel economy goals for the production of vehicles that are capable of running on alternative fuels such as E85, even though the vast majority of dual-fuel vehicles are operated entirely on gasoline.[104] Public policy should drive both improvements in fuel economy and sustainable expansion of biofuels in order to reduce fossil fuel use and achieve reductions in global warming pollution.

- **Restrain suburban sprawl** – Maryland has adopted a variety of policies to limit suburban sprawl, such as limiting state funding to designated growth areas. Counties also have implemented programs to keep growth within planned boundaries through zoning requirements and limiting water and sewer availability.

  However, sprawling growth in Maryland continues in many places. New low-density development continues in far-flung Baltimore and D.C. suburbs. Rapid population growth in western Maryland counties and the Eastern Shore threatens to bring even more traffic to Maryland's highways and to exacerbate global warming through ever-longer commutes. Maryland should work with municipalities to ensure that new growth takes place in a way that minimizes demand for highway travel and to encourage growth in already built-up areas with transportation infrastructure.

- **Expand and improve rail and bus transit systems** – Expansions in transit availability—as well as improvements in the frequency and quality of service—will be needed to expand Marylanders' range of transportation choices and provide alternatives to automobile use. The state has established a goal of doubling transit ridership by 2020 over 2000 levels.[108] This will require attracting commuters and others who currently drive, and providing better service to communities across the state.

  In Baltimore, the rail system needs to be expanded so that it serves the whole city, and bus service needs to be far more reliable. To serve D.C. suburbs in Prince George's and Montgomery counties, the state should advocate for construction of the Purple Line connected to the D.C. Metro system. Smaller communities need better bus service to carry residents to major retail and employment centers from low- and medium-density neighborhoods. Frequent, convenient service is essential for drawing new riders.

- **Keep transit fares reasonable** – With recent spikes in gasoline prices, more Maryland residents are looking for affordable alternatives to their automobile commutes. Unfortunately, the state's requirement that transit systems obtain 40 percent of their operating funds through ridership fees is forcing transit fares up and diminishing quality of service.[109] In addition, the lack of free transfers in Baltimore's transit system can double the cost of using transit for riders who much switch buses or to a train. Fare hikes can price out riders at the bottom of the income spectrum while discouraging long-distance automobile commuters from using transit instead. Rather than increasing fares, state leaders should use the opportunity posed by higher gasoline prices to encourage new transit ridership by stabilizing (and, if possible, reducing) transit fares.

- **Integrate smart growth, climate policy and transportation planning** – Transportation investments have impacts that go well beyond addressing specific traffic problems. They influence patterns of future land development and have a large environmental impact. Transportation planners in Maryland have begun to integrate these larger impacts into their evaluation of transportation projects, in some cases working with local citizens and municipalities in "corridor studies" that evaluate transportation problems within the broader context of land use and community development. The state should continue to move toward such an integrated approach, both in the evaluation of local projects and in statewide planning efforts. In addition, the state should ensure that "transportation demand management" measures—which often reduce the need for new capital expenses by better managing travel demand—are considered and evaluated alongside any proposals for new transportation infrastructure. Finally, the state should consider the global warming impact of all new transportation projects, so that Maryland residents can evaluate the impacts of various transportation choices on the climate.

By continuing to focus on the development of vibrant, compact communities whose residents have access to a variety of convenient, affordable transportation options, Maryland can stabilize the growth of vehicle travel, while reducing congestion on the state's highways and curbing the state's dependence on oil. The state should set a goal of stabilizing per-capita vehicle travel and develop transportation and land use policies sufficient to meet that goal.

Establish Energy Efficiency Programs

Potential Savings: 1.5 million metric tons of CO_2 by 2010; 3.1 million metric tons of CO_2 by 2020.

One of the most promising opportunities for reducing carbon dioxide emissions in Maryland is through improved energy efficiency. Stronger building codes (discussed later) and improved appliance efficiency standards reduce energy use in new buildings and from new appliances. Energy efficiency programs can help to reduce energy use in existing facilities.

Maryland has significant energy efficiency potential. Efficiency savings can be achieved with more efficient lighting, better insulation and weatherization of buildings, and more efficient furnaces, air conditioners and other appliances (causing the benefits of this strategy to partially overlap with the benefits of stronger appliance efficiency standards). Data presented in a study by the American Council for an Energy-Efficient Economy (ACEEE) suggest that Maryland can use less electricity in the future than it does today, getting more done with less energy. ACEEE compared the results of energy efficiency potential studies in states and regions across the country, finding that the average state could cost-effectively achieve a 24 percent reduction in electricity use over a period of 10 to 20 years.[110]

As the ACEEE analysis suggests, energy efficiency improvements are among the most promising and least costly ways Maryland can reduce its global warming emissions. But there are several hurdles to overcome. Potential users may not know about the technologies or have an accurate way of computing the relative costs and benefits of adopting them. Even when efficiency improvements are plainly justifiable in the long run, consumers may resist adopting technologies with increased up-front cost. In some cases, as with low-income individuals, consumers may not be able to afford the initial investment in energy efficiency, regardless of its long-term benefits.

Public policies and programs can help overcome these hurdles by offering rebates on efficient appliances and equipment, providing audits of residential and commercial energy use to identify opportunities for increased efficiency, installing energy efficiency measures in homes at a reduced price or for free for low-income households, and encouraging consumers to reduce their power use. Programs can also be designed to offer low-interest loans to businesses to invest in energy efficiency and to offer training programs to teach contractors how to improve building efficiency.

In many states, electric industry restructuring in the late 1990s brought about a new era of utility sector energy efficiency mechanisms, broadly categorized as public benefits funds and charges, but Maryland has invested next to nothing in efficiency. Maryland needs to aggressively pursue energy efficiency opportunities, starting with the following steps:

- The state should require electric utilities to spend 3 percent of total revenues (roughly $144 million annually) on cost-effective energy efficiency measures.[111] At this level of spending, Maryland could achieve a 6.5 percent reduction in electricity use versus projected levels by 2020, assuming a typical cost of saved energy.[112]

  This would put Maryland on par with states with the most successful energy efficiency programs, in terms of per-customer funding. For example, Vermont is the nation's leader in energy efficiency spending. Vermont's rate of electricity demand growth is less than half of what it would have been without energy efficiency programs, slashing Vermont's electricity consumption by close to 5 percent in 2005.[113]

  Energy efficiency measures can reduce natural gas consumption as well. Natural gas use could be reduced by 5.9 percent below projected levels by 2020 if Maryland were to dedicate 3 percent of residential, commercial and industrial natural gas purchases to energy efficiency programs.

- All energy providers in the state should be required to develop and implement efficiency programs to capture cost-effective efficiency potential. (The cost-effectiveness of efficiency measures should be compared to the cost of fuel, the environmental consequences of mining and burning fossil fuels, and the need for additional investments in energy delivery infrastructure.) In addition to requiring independent measurement, verification, and reporting of program expenditures and energy savings achieved, an improved state efficiency program should also lay out consequences for non-compliance.

  Maryland should also remove the perverse incentive against energy efficiency that utility companies currently experience. Because utility revenues are tied to the volume of power sold, increasing energy efficiency and reducing demand cuts into utilities' revenue. Utility company profits should be decoupled from the volume of power sold, thereby removing pressure for the power company to keep sales high.

Increasing funding for electricity and natural gas efficiency programs would help the state come closer to realizing its full, economically beneficial level of energy efficiency—delivering both reductions in global warming emissions and long-term cost savings to Maryland consumers.

Expand Use of Combined Heat and Power

Potential Savings: 1.3 million metric tons of CO_2 by 2010; 2.6 million metric tons of CO_2 by 2020.

Maryland has many opportunities to promote the use of combined heat and power, in which wasted energy from electricity generation is captured and used for other purposes.

America's electricity system is a good

source of reliable power, but is also loaded with inefficiencies. Power plants produce a large amount of waste heat during their operation. Similarly, the nation's long-distance transmission system results in the loss of between 5 and 10 percent of the electricity that crosses the wires on its way from power plants to homes and businesses.[114]

Maryland could reduce energy waste by promoting the use of combined heat and power (CHP) systems. CHP systems pair electricity generation and heating—enabling the waste heat from electricity generation to be used to provide space or water heating or to assist in industrial processes. While the average American power plant operates at a thermal efficiency of about 35 percent, CHP plants can achieve efficiencies of 80 percent or greater, meaning that more of the energy that goes into the plant is available for useful work.[115]

Various forms of CHP are already in use in Maryland, accounting for 825 megawatts of generation capacity, or the equivalent of roughly 7 percent of Maryland's generating capacity.[116] CHP can be implemented at the scale of a single industrial facility, in which a factory generates its own power and heat, or at the scale of a neighborhood, college campus or downtown area, where the steam or hot water from a power plant is used to provide space heating to multiple buildings.

A major expansion of CHP capacity is possible. Maryland has the technical potential for another 1,900 MW of CHP capacity.[117] To capture this potential, Maryland could offer technical assistance to facilities by assessing their potential for using CHP and helping to oversee the installation process, as well as by offering rebates or low-interest loans for the installation of CHP capacity.

Because CHP systems use fossil fuels, it is important that they are designed in such a way as to maximize their global warming emission reductions and energy savings and minimize air pollution. CHP plants should be required to meet minimum energy efficiency targets and include state-of-the-art air pollution controls.

Government "Lead By Example"

Potential Savings: 0.9 million metric tons of CO_2 by 2010; 2.0 million metric tons of CO_2 by 2020.

State and local governments are large users of energy in Maryland. Reducing energy use in the government sector not only has a direct impact on global warming pollution; it also sets an example for the private sector as to what can be achieved. Governments should be able to use long-term economic planning to realize that investing in efficiency and clean energy now will save money in the long run.

Maryland state government has already begun pursuing some measures to reduce its consumption of energy and contribution to global warming. Buildings that the state constructs or leases must meet the U.S. Green Building Council's Leadership in Energy and Environmental Design (LEED) silver standard, improving energy efficiency and other environmental attributes of buildings.[118]

The state should also engage in efforts to help municipal governments and public institutions (such as colleges and universities) improve their energy efficiency.

Specific targets the state should aspire to achieve include the following:

- A 25 percent reduction in energy consumption in government buildings statewide, up from the current 10 percent reduction target;
- A 50 percent reduction in energy consumption from new government buildings;
- Government purchases of at least 25 percent renewable energy;

- Replacing government vehicles with the most efficient vehicles available.

These goals are achievable. The American Institute of Architects has established a goal of reducing fossil fuel use in new buildings by 50 percent by 2010 and ensuring that new buildings be carbon neutral by 2035.[119] Financing upgrades does not have to be a challenge. Already, state agencies in Maryland can receive interest-free loans from the Maryland Energy Administration for improving the energy efficiency of state facilities.[120] Reduced energy costs can also help pay for retrofits.

Achieving these goals at both the state and the municipal government levels would lead to significant reductions in fossil fuel and electricity purchases. State government spent $248 million on energy in fiscal year 2006.[121] Given the recent increase in energy prices, which has played havoc with government budgets, measures that improve energy efficiency and invest in renewable energy aren't only good for the environment, but they also represent good fiscal stewardship for the taxpayers of Maryland.

Strengthen Residential and Commercial Building Energy Codes

Potential Savings: 0.1 million metric tons of CO_2 by 2010; 1.3 million metric tons of CO_2 by 2020.

Building codes were originally intended to ensure the safety of new residential and commercial construction. In recent years, however, building codes have been used to reduce the amount of energy wasted in heating, cooling, lighting and the use of electrical equipment. Because residential and commercial buildings can last for decades, adopting and enforcing strong building codes is crucial for avoiding excessive energy consumption over the long term.

Maryland could reduce energy use and pollution by adopting more rigorous codes. Maryland's current code is the 2003 International Energy Conservation Code (IECC).[130] (The newest version of the IECC was released in early 2006.) Once every three years, the state automatically updates its building codes if the International Code Council has updated its codes. Stronger codes than this are available.

A number of new homes in Maryland are already constructed to higher efficiency standards. In 2005, between 3 and 10 percent of new homes in Maryland were certified as "Energy Star" homes, which means they consume 15 percent less energy than homes built to the 2006 IECC standard.[131] In nine states, including New Jersey and Delaware, more than 20 percent of homes are constructed to Energy Star standards.

The global warming emission reductions projected here assume that Maryland adopts a residential code equal to the current Energy Star standard, beginning in 2010. On the commercial side, we assume that energy codes capable of reducing energy consumption by 25 percent from the current code are adopted effective in 2010.

In addition to setting a higher "floor" for building energy efficiency, Maryland can also take steps to raise the bar for exceptional energy efficiency performance. New government buildings and renovations to existing buildings should meet high energy efficiency standards. (See "Government Lead by Example" policy.) Maryland should also encourage the development of "zero energy" homes and commercial buildings, which pair strong energy efficiency measures with small-scale renewable energy production to dramatically reduce, or even eliminate, fossil fuel consumption.

Reduce the Number of Automobile Commutes

Potential Savings: 0.7 million metric tons of CO_2 by 2020.

Commutes to and from work make up a major share of vehicle travel in Maryland. Nationally, about 28 percent of all vehicle miles are traveled on the way to or from work.[122] Programs that require employers to provide transportation alternatives to their employees can go a long way toward reducing the number of vehicle-miles traveled on Maryland's highways.

Maryland currently offers several commute-trip reduction programs through the "Commuter Choice Maryland" program. Options include assistance with carpools/vanpools and help for employers who are considering offering a guaranteed ride home program, telecommuting options, or cash instead of parking benefits. In addition, employers who choose to give free transit passes to employees can claim a federal and state tax deduction worth half the cost of the transit pass.[123]

For many of these companies, commute-trip reduction programs make good business sense by improving employee morale, providing a desirable benefit for prospective employees, and reducing expenditures for parking. But the evidence suggests that mandatory trip-reduction programs—particularly those in which government plays a strong supporting role in helping employers achieve their commute-trip reduction goals—are more effective than voluntary efforts in bringing about large reductions in single-passenger commutes.

Between 1990 and 2000, for example, the percentage of Maryland workers driving to work alone increased from 70 percent to 74 percent, in line with the national trend.[124] Only two states experienced a decrease in the percentage of drive-alone commuters during the 1990s—Washington and Oregon. Not coincidentally, those two states also have effective mandatory employer trip reduction programs.

Washington State's program was enacted in 1991 and covers employers with 100 or more full-time employees at a single worksite in the state's nine most populous counties. The program requires employers to develop plans designed to reduce vehicle-miles traveled by employees in line with a set of increasingly stringent targets.[125] Oregon's program applies to employers with 50 employees or more at a single site in the Portland metropolitan area. It requires employers to offer incentives for the use of commuting alternatives with the potential of reducing commute trips by 10 percent over three years.[126]

Both programs have achieved results in reducing commuting travel. The Washington program removes 19,000 vehicles from the state's highways each morning, and the rate of single passenger commuting at worksites covered by the program dropped from 70.8 percent in 1993 to 65.7 percent in 2003. The number of commuting vehicle-miles traveled at those facilities would have been 5.9 percent higher were it not for the program. The Washington program also reduces global warming pollution by about 74,000 tons per year.[127] Oregon claims that 30 percent of employers in its program are meeting the 10 percent reduction target, and another 35 percent have seen trip reductions of between 1 and 9 percent, producing an annual reduction in vehicle-miles traveled of 35.4 million.[128]

A vigorous, mandatory trip reduction program for Maryland employers could achieve similar, if not better, results. Maryland's existing voluntary trip-reduction services, coupled with the state's transit infrastructure in the D.C. region, could provide a solid foundation for the expansion of trip-reduction efforts.

The carbon dioxide emission reductions projected for this strategy assume that large employers in the state (those with more than 100 employees) can reduce the number of single-passenger commuting trips by 20 percent by 2020. Among the programs and measures that can be used to achieve that goal are the following:

- Incentives and preferential parking privileges for carpool and vanpool drivers.
- Shuttle service to nearby transit stations.
- Programs to encourage and facilitate telecommuting.
- Flexible work schedules that allow workers to commute fewer days of the week.
- Parking "cash out," which allows employees to receive the value of employer-provided free parking for other uses if they choose not to drive to work.
- Emergency ride home programs that ensure that workers using transit are not stranded if they need to work late or return home early.
- Secure bicycle storage and changing facilities for employees who bike to work.
- Reimbursing bicycle and transit mileage for business trips when those modes are comparable in speed to driving.
- Creating a trip-reduction coordinator and actively promoting commuting benefits to employees.

In implementing an aggressive trip-reduction program, Maryland should be sensitive to the concerns of the business community—particularly those businesses that have already invested in voluntary commute trip-reduction efforts. Washington State's program, for example, includes businesses and local governments in the governance of the program, resulting in strong partnerships that enhance the program's success.

In addition, Maryland should be prepared to invest in helping businesses meet their commute-trip reduction goals. Commute-trip reduction has proven to be an extremely cost-effective way to reduce highway congestion, energy use and air pollution. In Washington State, for example, \$2.7 million in annual investment from the state has delivered more than \$37 million in reduced fuel expenditures and travel delay alone.[129] A relatively small investment of state funds, if coupled with a mandatory trip-reduction effort, could yield large dividends in reduced global warming emissions, reduced congestion, and reduced dependence on petroleum.

Require Energy-Saving Tires

Potential Savings: 0.3 million metric tons of CO_2 by 2010; 0.6 million metric tons of CO_2 by 2020.

Energy efficiency standards for replacement tires can improve the fuel economy of the existing vehicle fleet at a net savings to consumers.

Automobile manufacturers typically include gasoline-saving low-rolling resistance (LRR) tires on their new vehicles in order to meet federal fuel economy standards. However, energy-saving tires are generally not available to consumers as replacements when original tires have worn out. As a result, vehicles with replacement tires do not achieve the same fuel economy as vehicles with original tires.

The potential savings in fuel and carbon dioxide emissions are significant. A 2003 report conducted for the California Energy Commission found that LRR tires would improve the fuel economy of vehicles operating on replacement tires by about 3 percent, with the average driver replacing the tires on their vehicle when the vehicles

Other Transportation Strategies

Four strategies discussed above—enacting a low-carbon fuel standard, reducing the growth in vehicle travel, cutting automobile commutes, and requiring energy-saving tires—will help reduce emissions from transportation, but there are more ideas that Maryland could pursue on a regional or federal basis.

Improve Regional Freight Rail Infrastructure

Truck traffic clogs Maryland highways, produces vast amounts of pollution (including both global warming pollution and health-threatening smog and soot), and adds to the maintenance bill for Maryland highways. A regional investment in rail infrastructure could divert some freight traffic from trucks to rail.

Rail transport is a far more energy efficient way to move goods than by truck, taking about one-tenth the amount of energy.[134] In Maryland, however, the vast majority of freight travel goes by truck—94 percent of freight within the state, 72 percent of freight from the state and 53 percent of freight to the state travels by truck.[135]

This reliance on trucks occurs in part because much of the state's and region's rail infrastructure is outmoded. A recent study by a mid-Atlantic regional consortium identified numerous "choke points" in the region's rail system that reduce the system's capacity for carrying freight and passengers.[136]

Rail and truck freight traffic is projected to increase in coming years. The consortium projects that freight traffic between Baltimore and Washington, D.C., already one of the most heavily used sections of rail in the region, could increase by 80 percent by 2020. Assuming that rail traffic's share of this freight is equal to another 160,000 tons per day, this will require an additional 21 trains per day, or the addition of 9,000 trucks to Maryland's already congested roads.[137]

The consortium's report recommends a $6.2 billion investment in the mid-Atlantic region's rail system. By making that investment, the consortium concludes, the percentage of freight traveling through the region could approach the national average—eventually taking 25 percent of the trucks projected to travel the region's highways off the roads.[138]

Maryland should participate in cooperative efforts with the railroads, other states and the federal government to improve the region's freight rail infrastructure over the next two decades and encourage businesses to shift from truck to rail transport of freight wherever feasible.

Advocate for Heavy-Duty Truck Federal Fuel Economy Standards

Heavy-duty trucks are major consumers of fuel. Large tractor-trailers consumed about 14 percent of the fuel used by all highway vehicles nationally in 2004, and fuel consumption by large trucks has been increasing by more than 4 percent per year since the early 1990s.[139] As is the case with the light-duty vehicle fleet, fuel economy among the largest trucks has also been declining, dropping 5 percent between 1997 and 2002.[140]

(Continued, page 44)

reached four, seven and eleven years of age. The resulting fuel savings would pay off the additional cost of the tires in about one year, the report found, without compromising safety or tire longevity.[132]

Several potential approaches exist for encouraging the sale and use of LRR tires—ranging from labeling campaigns similar to the federal Energy Star program to mandatory fuel efficiency standards for all light-duty tires sold in the state. California recently chose the latter approach, adopting legislation requiring that replacement tires sold to consumers beginning in July 2008 have the same average energy efficiency as the original tires provided by automakers.[133] The state will rate the energy efficiency of different tires based on testing information provided by manufacturers. The law does not require that each tire be labeled with its efficiency rating, but the information will be readily available to Maryland to develop similar requirements.

A standards program that required the sale of LRR tires beginning in 2009 in Maryland—assuming the same tire replacement schedules and per-vehicle emissions reductions found in the California study—would ultimately reduce carbon dioxide emissions from light-duty vehicles by about 2 percent by 2020, while also providing a net financial benefit to consumers through reduced gasoline costs.

The Impact of the Strategies

The strategies listed above outline a path that would lead to significant reductions in carbon dioxide emissions in Maryland. We estimate that the specific strategies listed above would lead to a 33 percent reduction in carbon dioxide emissions below projected levels by 2020. Compared with 2006 emission levels, carbon dioxide emissions in 2020 would be 23 percent lower. (See Table 2 and Figure 8.)

(Continued from page 43)

Heavy-duty trucks are exempt from federal fuel economy standards. But significant increases in fuel economy for these trucks are possible at a net lifetime savings to vehicle owners. A 2004 study conducted by the American Council for an Energy-Efficient Economy (ACEEE) found that fuel economy improvements for tractor-trailers of 58 percent are achievable and cost-effective. The study also identified cost-effective improvements in fuel economy for other types of large trucks.[141] Calculations of cost-effectiveness were based on diesel fuel prices of $1.41 to $1.60 per gallon, well below the recent prices of $2.84 (and higher) charged at pumps across the United States.[142] As a result, the ACEEE estimates of cost-effective savings are likely conservative.

Imposing federal fuel-economy standards designed to increase the fuel economy of tractor-trailers by 50 percent would significantly reduce global warming pollution from the fast-growing freight transportation sector. The increase would be sufficient to raise the average fuel economy of heavy-duty trucks from approximately 5.7 MPG to about 8.5 MPG. The United States should also devise strategies to reduce fuel consumption and promote energy-efficient technologies in all medium- and heavy-duty trucks. Maryland should call upon the federal government to improve the fuel economy of trucks.

Figure 9. Projected Carbon Dioxide Emissions in Maryland with Recommended Strategies

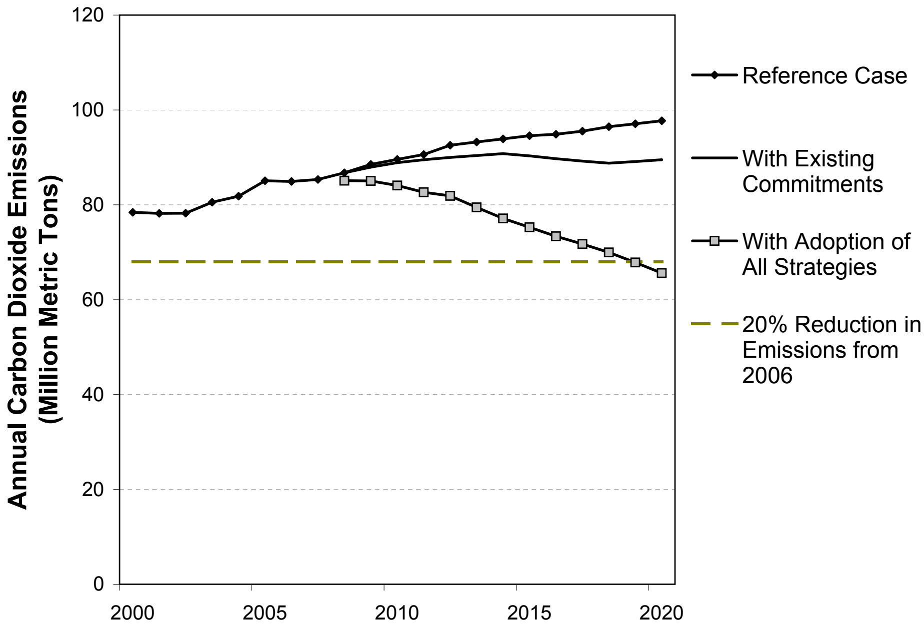


Table 2. Emission Reductions from the Policies (million metric tons of carbon dioxide)

Policy	2010	2020
Commitments Already Made		
Regional Greenhouse Gas Initiative	0.6	4.6
Clean Cars Program	0.1	3.5
2007 Amendments to Renewable Electricity Standard	0.0	0.8
Appliance Efficiency Standards	0.1	0.4
Recommended Policies		
Expanded Renewable Electricity Standard	0.0	4.8
Low-Carbon Fuel Standard	0.0	3.7
Reduce Growth in Vehicle Miles Traveled	0.9	3.3
Energy Efficiency Programs	1.5	3.1
Deploy Combined Heat and Power	1.3	2.6
Government "Lead By Example"	0.9	2.0
Stronger Residential & Commercial Building Codes	0.1	1.3
Commute Trip Reduction	0.0	0.7
Energy-Saving Replacement Tires	0.3	0.6
Total Savings (including actions already taken)	5.5	32.1
Savings needed to achieve 20 percent reduction by 2020		29.8

The First Step: Making a Firm Commitment

Each of the strategies listed above addresses global warming emissions from one sector of the state's economy. To adequately address a problem of the scale and reach of global warming, however, Maryland needs an overarching, statewide commitment to science-based reductions in global warming pollution.

Climate science is increasingly clear that the world's current emissions path will lead to large changes in the earth's temperature and thus our environment. If atmospheric concentrations of carbon dioxide stabilize at no higher than 450 ppm, global temperatures will rise 2.0° C (3.6° F).[143] This temperature increase will likely cause declines in agricultural production and may be enough to trigger melting of the Greenland and west Antarctic ice sheets, leading to a 4 to 6 meter rise in sea level over coming centuries. Temperatures greater than 2.5° C will have an even greater impact, putting 20 to 30 percent of species at risk of extinction. Temperatures above 3° C will trigger the loss of 30 percent of the world's wetlands.[144]

The challenge, therefore, is to keep temperatures below 2.0° C. This will require rapid action.

Already, carbon dioxide levels are at least 379 ppm and are rising by 1.9 ppm per year.[145] At this rate, atmospheric concentrations of carbon dioxide will surpass 450 ppm within 37 years. However, annual worldwide emissions are increasing, and thus if atmospheric concentrations of carbon dioxide are to stabilize at 450 ppm or lower, worldwide emissions of global warming pollution will need to begin to decline by 2020 at the latest.[146] By 2050, emissions will need to be just a fraction of today's levels.

Maryland will not able to reduce its global warming emissions by 2020 by tackling the problem with just one policy at a time. Instead, the state needs to set enforceable targets for global warming emissions that are consistent with the latest climate science. Policymakers could then adopt individual policies to cut pollution from specific sources. In addition, having a firm goal would allow the state to prevent increases in global warming emissions from portions of the economy that are not covered by specific clean energy policies and from activities other than energy use (such as methane emissions from landfills).

In 2006, the state of California adopted the nation's first statewide cap on global warming emissions, requiring emissions to be reduced to 1990 levels by 2020. Maryland should adopt a similar policy, requiring that emissions be 20 percent below 2006 levels in 2020 and 80 percent in 2050. The state should also encourage neighboring states and the federal government to do the same.

Maryland has an important role to play in the broader debate over efforts to reduce global warming emissions. First, Maryland should set its own, science-based targets for reducing global warming emissions and adopt the public policies necessary to ensure that they are met. Second, Maryland can demonstrate policies that are both effective for reducing global warming emissions and also good for the economy. Finally, as one of the states likely to be severely affected by global warming, Maryland leaders have a responsibility to communicate the stakes of U.S. policy on global warming emissions to federal officials.

Methodology and Technical Discussion

General Assumptions and Limitations

This report makes projections of Maryland's future emissions of carbon dioxide and provides estimates of the emissions impacts of a variety of public policy strategies for addressing global warming.

There are several general assumptions and limitations that shape this analysis.

First, we rely primarily on energy consumption data and projections from the U.S. Energy Information Administration (EIA) to estimate past, present and future global warming emissions in Maryland. Emissions through 2004 are based on state-specific EIA estimates of energy consumption in Maryland. Emissions for 2005 and future years are based on projected rates of growth in energy use for the South Atlantic region (which includes Maryland along with Delaware, Florida, Georgia, North Carolina, South Carolina, Virginia, West Virginia and Washington, D.C.) adjusted to reflect the lower projected population growth in Maryland versus the region as a whole. Specific conditions in Maryland may be different than those in the region as a whole. Future projections of energy use depend on a range of assumptions as to the price and availability of various sources of energy and energy-consuming technologies. Thus, the projections should be viewed as one possible scenario for the future, though other scenarios are certainly possible.

Second, this analysis includes only emission of carbon dioxide from energy use and electricity production in Maryland. Global warming is also exacerbated by emissions of other gases (such as methane and nitrous oxide) within Maryland, by emissions of carbon dioxide resulting from the production of electricity in other states for use in Maryland, and by "upstream" emissions resulting from the energy consumed to produce goods and services used by Maryland residents. Thus, this analysis is not a comprehensive view of the cumulative impact of Maryland on the global climate, but rather focuses only on the most significant means by which Maryland affects the global climate (through energy-related emissions of carbon dioxide) and policy tools for reducing that impact.

Third, this emission reduction scenario assumes that Maryland achieves greater reductions in the electricity sector than under the current proposal for implementing RGGI. Increased energy efficiency and generation of renewable energy will allow Maryland to go far beyond the 10 percent reduction in electric sector emissions envisioned in RGGI. However, under the current RGGI system, any emission reductions in the electric sector that go beyond the 10 percent reduction required of Maryland may result in increased emissions in other states. Achieving these reductions in Maryland, therefore, assumes that other states in the RGGI region make similar reductions.

All fees, charges and other monetary values are 2006 dollars, unless otherwise noted.

Baseline Emissions Estimates

Baseline estimates of carbon dioxide emissions from energy use for 2004 and prior years were based on energy consumption data from EIA's State Energy Data database, downloaded from www.eia.doe.gov on 18 April 2007. An exception to this methodology was made for the projection of future generation from wind power, since Maryland had no wind power generation in 2005, but has issued a permit for the construction of a wind farm. We assumed that the facility will begin producing power in 2008. We extrapolated future growth in wind power generation based on a 2008 baseline equivalent to the annual estimated production of electricity from the new wind farm, based on American Wind Energy Association, *Wind Project Database: Maryland*, downloaded from www.awea.org/projects/maryland.html, 24 October 2006.

To calculate carbon dioxide emissions, energy use for each fuel in each sector (in BTU) was multiplied by carbon coefficients as specified in EIA, *Documentation for Emissions of Greenhouse Gases in the United States 2003 ("Documentation")*, May 2005.

Adjustments were made for storage of carbon through non-fuel industrial consumption of natural gas and petroleum products using data and following the methodologies described in EIA, *Documentation*. To calculate the percentage of various petroleum products used for non-fuel purposes, we either used EIA's assumptions as described in the document above, or compared the quantity of fuels used for non-fuel purposes in *Documentation* with total U.S. consumption of the products from the State Energy Data database. We derived the percentage of carbon dioxide that is released from non-fuel uses of petroleum and natural gas from values presented in *Documentation*.

Combustion of wood, biomass and waste was excluded from the analysis per EIA, *Documentation*. This exclusion is justified by EIA on the grounds that wood and other biofuels obtain carbon through atmospheric uptake and that their combustion does not cause a net increase or decrease in the overall carbon "budget." Municipal solid waste is considered a "biofuel" by EIA and its emissions are excluded.

Future Year Projections

Projections of energy use and carbon dioxide emissions for Maryland are generally based on applying the South Atlantic Region year-to-year projected growth rate for each fuel in each sector from EIA's *Annual Energy Outlook 2006 (AEO 2006)* to the Maryland baseline emissions estimate for 2004. Because Maryland's population (and presumably its economic activity) is projected to increase at a slower rate than the South Atlantic region as a whole, we multiplied the year-by-year growth rate from *AEO 2006* by the ratio between the projected population growth rate in Maryland (from the U.S. Census Bureau, increased to include new residents as a result of the Base Realignment and Closing process), and the regional population growth rate assumed in *AEO 2006*. BRAC-related population growth was obtained by multiplying estimated new households (from Maryland Department of Business and Economic Development, Office of Military and Federal Affairs, *2005 BRAC State of Maryland Impact Analysis: 2006-2020*, 2007) by average household size in Maryland (calculated from population in Maryland divided by number of households, per U.S. Census Bureau.)

We further assumed that not all of the major public policy steps described in the "Commitments Already Made" section are factored into the estimates of energy use in *AEO 2006*. EIA states that *AEO 2006* reflects all legislation and policies adopted as of October 31, 2005. Maryland's original appliance efficiency standards and 2004 renewable electricity standard were adopted well before that deadline. However, *AEO 2006* does not include energy savings from the RGGI program, which has still not been formally adopted in the states, from the Clean Cars Program, the 2007 amendments to the renewable electricity standard, or the new appliance efficiency standards.

Carbon Dioxide Reductions from Electricity Savings and Renewable Energy Use

Measures that reduce electricity consumption in Maryland or that expand renewable electricity generation were assumed to reduce the generation of electricity in Maryland by a proportional amount. That is to say, the proportion of electricity Maryland is projected to import from other states to serve local demand was held constant in this analysis. To account for this, reductions in net generation from these strategies were multiplied by 0.78 to reflect the ratio of electricity generation in Maryland to electricity sales in the state in 2004, per EIA, *State Electricity Profiles 2004*.

Carbon dioxide emission reductions resulting from reduced demand for fossil and nuclear-powered generation in Maryland were calculated as follows:

Net electricity generation from each type of fuel was estimated by multiplying consumption of each fuel for electricity generation in Maryland (from the EIA State Energy Data database) by the average heat rate of generators using that fuel for the Mid-Atlantic Area Council (MAAC) electric reliability region (of which Maryland was a part prior to MAAC's merger into ReliabilityFirst Corporation). Heat rates for fossil fuel-fired power plants were calculated by dividing the amount of each fuel consumed in the MAAC region by the net generation from that fuel (with both figures coming from the supplementary tables to EIA's *AEO 2006*). For nuclear and renewable electricity generation, the heat rate was assumed to be the average for fossil fuel power plants in the United States, per EIA, *State Energy Consumption, Price and Expenditure Estimates (SEDS), Technical Notes for Updated Data, Appendix B*, downloaded from www.eia.doe.gov/emeu/states/_seds_updates_tech_notes.html, 19 July 2006.

Reductions in net fossil fuel generation from energy efficiency improvements and renewable energy (calculated as described below for each strategy) were assumed to reduce the need for electricity generation versus the reference case projection. New (post-2007) natural gas and nuclear capacity was offset first, followed by coal-fired generation. Offsets were applied in keeping with the current ratio of in-state generation versus imports.

The resulting estimates of net generation by fuel after the policy measures were then multiplied by the heat rate (derived as described above) to estimate the amount of fuel consumed for electricity generation. Fuel consumption was then multiplied by the appropriate carbon coefficient to estimate carbon dioxide emissions.

Emission Reductions from the Strategies

Commitments Already Made

Regional Greenhouse Gas Initiative (RGGI)

To estimate the impact of RGGI, we assumed that carbon dioxide emissions from Maryland's electricity sector would be equivalent to the allowance allocation for Maryland as described in the Regional Greenhouse Gas Initiative, *Second Amendment to Memorandum of Understanding*, 1 May 2007.

This method is likely to overestimate the emission reductions from RGGI because it does not account for a variety of flexibility mechanisms (such as offsets) and safety valves that could allow electric generators to emit more carbon dioxide than called for under the RGGI cap. Because the RGGI model rule has not been adopted by the states, the extent of the flexibility mechanisms available to generators and the scope of the program remain undetermined, the exact emission reductions that will be delivered by RGGI are difficult to predict.

Clean Cars Program

The percentage reduction in carbon dioxide emissions that can be expected from implementation of the Clean Cars Program was based on estimated percentage reductions in per-mile global warming emissions due to the standards per California Environmental Protection Agency, Air Resources Board, *Staff Report: Initial Statement of Reasons for Proposed Rulemaking, Public Hearing to Consider Adoption of Regulations to Control Greenhouse Gas Emissions from Motor Vehicles*, 6 August 2004.

To calculate the reductions Maryland could expect from the standards, we sought to answer the following questions:

1) What percentage of the vehicle-miles traveled each year would be from vehicles of the various model years/ages? This would determine the emission standard to which the vehicles are held and how much carbon dioxide the vehicles would emit per mile.

2) What percentage of vehicle-miles will be traveled in cars versus SUVs? The Clean Cars Program includes different standards for cars and light trucks.

3) What would carbon dioxide emissions have been were the Clean Cars Program not in place? And what would emissions be under the standards?

1. Estimating Vehicle-Miles Traveled by Age

To estimate the amount of miles that would be traveled by vehicles of various ages, we relied on data on VMT accumulation by vehicle age from the U.S. Department of Transportation's 2001 *National Household Transportation Survey* (NHTS), downloaded from nhts.ornl.gov/2001/index.shtml, 21 June 2006. We used the estimates of the number of miles driven per vehicle by vehicles of various ages from NHTS to estimate the percentage of total VMT in any given year that could be allocated to vehicles of various model years. (To eliminate year-to-year anomalies in the NHTS data, we smoothed the VMT accumulation curves for cars and light trucks using several sixth-degree polynomial curve fits.)

2. Estimating the Percentage of Vehicle-Miles Traveled by Cars and Light Trucks

To estimate the percentage of vehicle-miles traveled accounted for by cars and light-duty trucks, we relied on two sources of data: actual VMT splits by vehicle type for 2000 through 2002 from the Federal Highway Administration, *Highway Statistics* series of reports and projections of future VMT splits output from the EPA's MOBILE6 mobile source emission estimating model. (Maryland-specific data on VMT splits are unavailable but the state has a higher ratio of registered cars to trucks than the national average, according to Federal Highway Administration, *Highway Statistics 2002*, October 2003, Table MV-1. This should make our analysis of the programs' benefits slightly lower than will likely occur because per-mile emission reductions for cars are greater than for trucks and total emission reductions are undercounted in Maryland by using national figures for car and light truck registrations.)

EPA's projections of the VMT split among cars and light-duty trucks assign significantly more VMT to light-duty trucks than has been the case over the past several years, according to FHWA data. However, EPA's long-term projection that light trucks will eventually represent 60 percent of light-duty vehicle sales by 2008 appears to be reasonable in light of the continued trend toward sales of light trucks.

In order to estimate a trend that reflects both the more car-heavy current makeup of VMT and the long-term trend toward increasing travel in light trucks, we created two curves, one extrapolating the continued linear decline in the car portion of light-duty VMT based on trends in FHWA data from 1990 to 2002 and another using the EPA MOBILE6 estimates. We then assumed that the split in VMT would trend toward the EPA estimate over time, so that by 2020, cars are responsible for approximately 50 percent of light-duty VMT.

VMT in the light-truck category were further disaggregated into VMT by "light" light trucks (in the California LDT1 category) and heavier light trucks (California LDT2s), per EPA, *Fleet Characterization Data for MOBILE6: Development and Use of Age Distributions, Average Annual Mileage Accumulation Rates, and Projected Vehicle Counts for Use in MOBILE6*, Septempber 2001.

3. Estimating Carbon Dioxide Emissions With and Without the Standards

Baseline carbon dioxide emissions without the Clean Cars Program are based on assumptions about future vehicle fuel economy from EIA, *AEO 2006*. These fuel economy estimates were translated into per-mile carbon dioxide emission factors assuming that consumption of a gallon of gasoline produces 8,869 grams (19.6 pounds) of carbon dioxide. This figure is based on carbon coefficients and heat content data from U.S. Department of Energy, Energy Information Administration, *Emissions of Greenhouse Gases in the United States 2001, Appendix B*. Fuel economy estimates for years prior to 2003 were based on EPA laboratory fuel economy values from EPA, *Light-Duty Automotive Technology and Fuel Economy Trends: 1975 Through 2004*, April 2004. Both the EIA estimates of future fuel economy and the EPA estimates of historic fuel economy were multiplied by an "on-road degradation factor" (representing the degree by which real-world fuel economy falls below EPA laboratory results) from *AEO 2006*.

Emissions from vehicles complying with the standards were estimated by multiplying the percentage reduction in emissions attributed to the standards (obtained from CARB as described above) for each model year to the 2002 emissions level for that class of vehicles. For all years until 2016, vehicles sold by intermediate and small vehicle manufacturers were assumed not to comply with the standards (due to an exemption in the California law) and were assigned emissions at the same rate as calculated for the reference case scenario (described above). Intermediate and small manufacturers were assumed to sell 12.7 percent of cars and 6 percent of light trucks, based on national estimates from Ward's Communications, *2003 Ward's Automotive Yearbook*, 233. In 2016 and subsequent years, small and intermediate manufacturers were assumed to achieve carbon dioxide emission reductions of 25 percent for cars and 18 percent for light trucks per a compliance option for those manufacturers described in Title 13 CCR 1961.1(C).

Fleet Emission Projections

Based on the above data, scenarios were created comparing the reference case (essentially, what emissions from the fleet would have been without the Clean Cars Program) and a policy case. Emission factors for each vehicle class and model year were calculated as described above, and multiplied by the share of total VMT attributed to vehicles of that vehicle class and model year. Total emissions were then summed across vehicle classes and model years to arrive at an estimate of total emissions from the light-duty fleet in any given year. The emissions estimate for the policy case was then compared to the emissions estimate from the reference case to arrive at an estimate of the percentage by which the Clean Cars Program would reduce light-duty vehicle emissions in any particular year. This estimate was then multiplied by the estimated amount of emissions from light-duty vehicle gasoline consumption in our reference case to arrive at the total reduction that would result from implementation of the Clean Cars Program.

In addition to the above, we made the following assumptions:

- **Rebound effects** – Research has shown that improved vehicle fuel efficiency often results in an increase in vehicle-miles traveled. By reducing the marginal cost of driving, efforts to improve efficiency provide an economic incentive for additional vehicle travel. Studies have found that this "rebound effect" may reduce the carbon dioxide emission savings of fuel economy-improving policies by as much as 20 to 30 percent.[147] To account for this effect, carbon dioxide reductions in each of the scenarios were discounted by 5 percent. This estimate is moderate: in its own analysis using California-specific income and transportation data, CARB estimated a rebound effect ranging from 7 percent to less than 1 percent.[148]

- **Mix shifting** – We assumed that neither of the policies under study would result in changes in the class of vehicles purchased by Maryland residents, or the relative amount that they are driven (rebound effect excluded). In addition, we assumed that the vehicle age distributions assumed by EPA remain constant under each of the policies. In other words, we assumed that any increase in vehicle prices brought about by the global warming emission standards would not dissuade consumers from purchasing new vehicles or encourage them to purchase light trucks when they would otherwise purchase cars (or vice versa). Mix shifting impacts such as these are quite complex and modeling them was beyond the scope of this report, but they do have the potential to make a significant impact on future carbon dioxide emissions.

Renewable Electricity Standard

Savings from Maryland's 7.5 percent renewable energy standard, adopted in 2004, are already included in the baseline scenario. The amendments to the renewable electricity standard, adopted in 2007, are not included. Additional savings from the revised policy were calculated as described above in "Carbon Dioxide Reductions from Electricity Savings and Renewable Energy Use."

Appliance Efficiency Standards
Estimates of potential energy savings from appliance efficiency standards were based on state-specific estimates for Maryland from American Council for an Energy-Efficient Economy (ACEEE) and Appliance Standard Awareness Project (ASAP), *Leading the Way: Continued Opportunities for New State Appliance and Equipment Efficiency Standards*, March 2006. Electricity and natural gas savings estimates were prorated between the anticipated date on which the standards would be imposed and 2020. Standards related to heating and lighting energy use were assumed to be covered under building codes for new buildings, and 30 percent of the savings from those measures were eliminated in order to avoid double-counting in the combined policy case.

Additional Strategies

Low-Carbon Fuel Standard
Estimates of emission reductions from the adoption of a low-carbon fuel standard are based on an assumption that the state will require a 1 percent reduction in the carbon intensity of motor gasoline and diesel in the transportation sector beginning in 2011. The standard will increase by 1 percent per year until 2020, when the standard will require a 10 percent decrease in carbon emissions from transportation-related gasoline and diesel consumption.

Reduce Growth in Vehicle Travel
Estimated carbon dioxide reductions from reduced growth in vehicle travel are based on the assumption that per-capita vehicle travel in Maryland is stabilized beginning in 2008. Future VMT growth increases are held to the rate of population growth projected for Maryland in U.S. Census Bureau, *Interim State Population Projections 2005*, 21 April 2005, Table 7, adjusted as described earlier for BRAC-related growth. An annual rate of population growth was calculated from the Census Bureau's projections of population growth by decade. This rate of growth was compared to the rate of VMT growth implied by EIA's projections of increases in transportation gasoline consumption and fuel economy from *AEO 2006*. The ratio of these two VMT growth rates was then applied to the year-over-year growth rate in transportation gasoline consumption from *AEO 2006* and this was compared to the gasoline consumption projection in the reference case to determine the percentage by which gasoline consumption would be reduced through slower growth in vehicle travel.

We assumed that the reduction in vehicle travel growth in this scenario would take place as a result of changes in land-use patterns and availability of transportation alternatives. As a result, the carbon dioxide reductions from this scenario are in addition to, and not a substitute for, VMT reductions obtained through other strategies, such as commute-trip reduction programs.

Energy Efficiency Programs
Projections of benefits from electricity efficiency programs were based on average savings from existing electricity efficiency programs nationwide. Energy savings per percent of utility revenue were obtained from Martin Kushler, Dan York, and Patti Witte, American Council for an Energy-Efficient Economy, *Five Years In: An Examination of the First Half-Decade of Public Benefits Energy Efficiency Policies*, April 2004. Savings from each of the programs included in this study were plotted on a graph and used to generate a linear equation

for the percentage of annual energy use that could be reduced via efficiency per percentage of utility revenue devoted to energy efficiency programs. These equations were then used to generate estimated percentage savings for proposed electricity efficiency programs funded with 3 percent of utility revenue.

Cumulative savings from previous energy efficiency measures in any particular year were based on the ratio between lifetime savings and annual savings from electric and natural gas efficiency measures in New Jersey Board of Public Utilities, Office of Clean Energy, *New Jersey's Clean Energy Program 2005 Annual Report*, undated, which was approximately 9-to-1 for electricity savings and 18-to-1 for natural gas savings. Total electricity savings for any particular year were estimated to be the annual savings for measures implemented in that year plus the annual savings for measures implemented in the previous eight years for electricity and the previous 17 years for natural gas. This is a simplistic assumption; in reality, the degree to which energy efficiency investments made in any particular year deliver energy savings in a future year depend on the type of measures undertaken (for example, installing an energy-efficient light bulb may deliver energy savings for a couple of years while installing an energy-efficient furnace may deliver savings for decades).

For electricity savings, reductions in site energy use were divided by 0.9 (to account for transmission losses) to estimate the amount of net generation that would be displaced. Carbon dioxide emission reductions were estimated according to the method described in "Estimating Emission Reductions from Energy Efficiency and Renewable Energy," above.

Natural gas savings were based on the assumption that investments in natural gas efficiency programs would equal 3 percent of natural gas revenues, as presented in Energy Information Administration, *State Energy Consumption, Price and Expenditure Estimates*, 24 October 2006. The amount of natural gas savings this would yield was calculated based on the cost of natural gas efficiency savings achieved in New Jersey, per New Jersey Board of Public Utilities, Office of Clean Energy, *New Jersey's Clean Energy Program 2005 Annual Report*, no date. Savings were assumed to be reduced by 25 percent beginning in the sixth year, as the cheapest efficiency options would have already been implemented.

Expanded Use of Combined Heat and Power

Future commercial and industrial power generation from CHP were estimated based the potential identified in Energy and Environmental Analysis, Inc., *Installed CHP in 2005*, downloaded from www.nrbp.org/events/meetings/060524/, 24-25 May 2006. We assumed that the 1,944 MW of CHP described in the above study would be phased in linearly between 2008 and 2020, with no further increases after 2020. The amount of net electricity generation that would be displaced by CHP was calculated assuming a 63 percent capacity utilization factor imputed from current U.S. CHP generation and generation capacity as presented in American Council for an Energy-Efficient Economy, *Combined Heat and Power: The Efficient Path for New Power Generation*, downloaded from www.aceee.org/energy/chp.pdf, 20 July 2006. We further assumed that generation from CHP would offset an additional 10 percent of generation from centrally produced power to account for transmission losses from centrally produced power.

Additional global warming emissions from natural gas consumed in CHP applications were estimated based on a heat rate of 5,000 BTU/kWh from Western Resource Advocates, *A Balanced Energy Plan for the Interior West*, 2004.

Government "Lead By Example"
Baseline estimates of public sector energy consumption in Maryland came from the following sources:

- **Government buildings** – Government building energy use was estimated by dividing estimated energy consumption in government buildings by estimated energy use in all commercial buildings based on data from EIA, *2003 Commercial Buildings Energy Consumption Survey (CBECS)*. For electricity and natural gas, mid-Atlantic regional figures were used. No data on heating oil was available. The resulting percentage was then applied to Maryland commercial energy consumption in the reference case to arrive at an estimate of government building energy use in Maryland. Fuels not included in *CBECS* were assumed not to be used in Maryland government buildings.

- **Government vehicles** – Government vehicle energy use was estimated by dividing public sector gasoline consumption with total gasoline consumption in Maryland from U.S. Department of Energy, Federal Highway Administration, *Highway Statistics 2004*, October 2005. Government vehicle diesel use was assumed to represent the same percentage of diesel use as government vehicle gasoline use.

To these baseline estimates of government energy use, we then applied the following strategies:

- 25 percent reduction in government energy use, beginning in 2008 and phased in over 10 years;

- 50 percent reduction in new building energy consumption, assuming that all additional government building energy consumption beyond 2007 takes place in new buildings;

- 25 percent of electricity from renewable energy, assuming that renewable energy displaces nuclear and fossil fuel generation as described above;

- Replacing government vehicles with the most efficient vehicles available. We assume that the most efficient vehicles are 30 percent more efficient than current vehicles based on the average difference between the average fuel economy of vehicles in each vehicle class and the most-efficient vehicle in that class from U.S. Environmental Protection Agency, *Light-Duty Automotive Technology and Fuel Economy Trends: 1975 Through 2005*, July 2005.

Residential and Commercial Building Codes
The projected impact of building energy codes is based on the assumption that building code improvements will only affect the energy efficiency of new buildings. Since building codes affect both new buildings and major renovations of existing buildings, the emission reductions projected here are likely conservative.

For residential codes, the proportion of projected residential energy use from new homes was derived by subtracting estimated energy use from homes in existence prior to 2008 from total residential energy use for each year based on *AEO 2006* growth rates. Consumption of energy by surviving pre-code homes was calculated by assuming that energy consumed per home remains stable over the study period and that 0.3 percent of homes are retired each year, per EIA, *Assumptions to AEO 2006*.

For commercial building codes, commercial building retirement percentages were estimated for Maryland by averaging the approximate median age of commercial floorspace in the South Atlantic Region and Mid-Atlantic Region based on data from EIA, *2003 Commercial Building Energy Consumption Survey (CBECS)*; estimating a weighted-average "gamma" factor (which approximates the degree to which buildings are likely to retire at the median age); and inputting the result into the equation, as described in EIA, *AEO 2006*.

Surviving Proportion = 1/(1+(Building Age/Median Lifetime)$^{\text{Gamma)}}$

Baseline 2007 commercial energy demand was then multiplied by the percentage of surviving per-code commercial buildings to estimate the energy use from buildings not covered by the code.

Energy savings from code improvements were based on the following assumptions:

For residential codes, a 15 percent reduction in electricity, oil and natural gas consumption in new homes beginning in 2010, based on an estimated 15 percent reduction that would result from replacing Maryland's current building code with a code that is roughly equal to the 2006 Energy Star standard (from U.S. Environmental Protection Agency, U.S. Department of Energy, *Guidelines for Energy Star Qualified New Homes*, downloaded from www.energystar.gov/index.cfm?c=bldrs_lenders_raters.homes_guidelns09, 20 July 2006).

For commercial codes, we assume a 25 percent reduction in consumption of all fuels in new commercial buildings, beginning in 2010 from the adoption of more stringent codes. This goal is fully achievable: the American Institute of Architects has established a goal of reducing fossil fuel use in new buildings by 50 percent by 2010 (American Institute of Architects, *Architecture 2030: The 2030 Challenge*, January 2006).

Reduce the Number of Automobile Commutes

The impact of a mandatory commute-trip reduction program in Maryland is based on the following assumptions:

1) The program would include all Maryland employers with more than 100 employees (regardless of whether those employees work at a single worksite or multiple worksites).

2) The program will include a goal of reducing commuting miles traveled by 1 percent in 2010 and 2011, with the goal increasing by 2 percent each year until a 20 percent reduction in commuting miles traveled is achieved in 2020.

3) Compliance with the program is 75 percent.

Commutes were estimated to account for approximately 27 percent of vehicle travel in Maryland based on national estimates from U.S. Department of Transportation, Federal Highway Administration, *Summary of Travel Trends: National Household Transportation Survey 2001*, December 2004. Workers at firms with more than 100 employees were assumed to represent 63 percent of all Maryland workers based on U.S. Census Bureau, *Statistics of U.S. Businesses: 2001: Maryland—All Industries by Employment Size of Enterprise*, downloaded from www.census.gov/epcd/susb/2001/md/MD--.HTM, 23 October 2006.

Energy-Saving Tires

Savings from the use of low-rolling resistance replacement tires were estimated using a methodology developed for RIPIRG Education Fund, *Cars and Global Warming*, Winter 2005. Emission reductions were generated by reducing carbon dioxide emission factors by 3 percent from baseline assumptions for vehicles reaching four, seven and 11 years of age, beginning in 2009, per California Energy Commission, *California Fuel-Efficient Tire Report, Volume II*, January 2003. Vehicle age estimates were based on VMT accumulation rates presented in U.S. Environmental Protection Agency, *Fleet Characterization Data for MOBILE6*, September 2001. This estimate assumes that the tire stock will completely turn over, that is, that LRR tires will supplant non-LRR replacement tires in the marketplace through a state requirement. Other policies to encourage, but not mandate, LRR tires would likely produce reduced savings.

Combined Policy Case

The combined policy case includes emission reductions from all the strategies described above, with the following exceptions:

- The policy case does not include emission reductions from some appliances subject to both appliance efficiency standards and updated building codes.

- Emission reductions achieved to comply with RGGI overlap with savings accomplished through energy efficiency and increased renewable energy generation and thus were not included.

Notes

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2 John Spears and Andre Van Rest, International Center for Sustainable Development, *Economic Development Potential of Clean Energy Technology in Maryland and Feasibility Study for a Maryland Clean Energy Center*, 31 December 2006.

3 Intergovernmental Panel on Climate Change, *Climate Change 2007: The Physical Science Basis: Summary for Policymakers*, February 2007.

4 Ibid.

5 J. Hansen, et al., NASA Goddard Institute for Space Studies, *GISS Surface Temperature Analysis: Global Temperature Trends: 2005 Summation*, downloaded from data.giss.nasa.gov/gistemp/2005/, 23 May 2006.

6 Figure obtained from: Intergovernmental Panel on Climate Change, *Climate Change 2007: The Physical Science Basis, Summary for Policy Makers*, February 2007.

7 See note 3.

8 Ibid.

9 R.K. Pachauri and Babu Jallow, Intergovernmental Panel on Climate Change, *Climate Change 2007: The Physical Science Basis*, Power Point presentation, 6 February 2007.

10 See note 3.

11 See note 9.

12 See note 3.

13 Ibid.

14 Kerry Emanuel, "Increasing Destructiveness of Tropical Cyclones Over the Last 30 Years," *Nature* 436:686-688, 4 August 2005.

15 P.J. Webster et al., "Changes in Tropical Cyclone Number, Duration, and Intensity in a Warming Environment," *Science* 309(5742):1844-1846, 16 September 2005.

16 Intergovernmental Panel on Climate Change, *Climate Change 2007: Climate Change Impacts, Adaptation and Vulnerability: Summary for Policymakers*, April 2007.

17 U.S. Environmental Protection Agency, Office of Policy, Planning and Evaluation, *Climate Change and Maryland*, September 1998.

18 Maryland State Climatologist Office, *Maryland Temperature and Precipitation Trends*, downloaded from www.atmos.umd.edu/~climate/, 28 August 2006.

19 See note 17.

20 Data for a weather station near Waldorf, Maryland, provided by Emily Becker, Assistant State Climatologist, Department of Atmospheric and Oceanic Science, University of Maryland, College Park, 1 November 2006.

21 See note 17.

22 Tom Pelton, "New Maps Highlight Vanishing E. Shore," *Baltimore Sun*, 30 July 2004. The state is sinking because glaciers compress the land

beneath them and create a bulge in surrounding areas, such as Maryland. With the glaciers now gone, the bulge beneath Maryland is subsiding.

23 Net effect: U.S. Environmental Protection Agency, National Park Service, and U.S. Fish and Wildlife Service, *Climate Change, Wildlife, and Wildlands: Chesapeake Bay and Assateague Island*, downloaded from yosemite.epa.gov/oar/globalwarming.nsf/UniqueKeyLookup/SHSU5BPPVT/$File/CS_Ches.pdf, 19 October 2005; 3,100 miles: See note 17; 260 acres: See note 22.

24 U.S. Environmental Protection Agency, National Park Service, and U.S. Fish and Wildlife Service, *Climate Change, Wildlife, and Wildlands: Chesapeake Bay and Assateague Island*, downloaded from www.epa.gov/climatechange/wycd/downloads/CS_Ches.pdf, 16 May 2007.

25 Ibid.

26 University of Maryland Center for Environmental Science, Integration Application Network, *Hurricane Isabel and Sea Level Rise*, downloaded from ian.umces.edu/pdfs/iannewsletter6.pdf, 7 September 2006.

27 Michael Kearney and J. Court Stevenson, University of Maryland, *Dissecting and Classifying the Impacts of Historic Hurricanes on Estuarine Systems* (presentation), available at www.climate.org/topics/weather/hurricane-isabel.shtml, 7 September 2006.

28 See note 3. See also: World Meteorological Organization, *First WMO Greenhouse Gas Bulletin: Greenhouse Gas Concentrations Reach New Highs in 2004* (press release), 14 March 2006.

29 American Academy for the Advancement of Sciences, *New Research in* Science *Shows Highest CO_2 Levels in 650,000 Years* (press release), 28 November 2005. See also note 3.

30 See note 6.

31 Percentage contribution to global warming in this section based on U.S. Department of Energy, Energy Information Administration, *Emissions of Greenhouse Gases in the United States*, Executive Summary, March 2006.

32 Ibid.

33 See, for example, James Hansen and Larissa Nazarenko, "Soot Climate Forcing via Snow and Ice Albedos," *Proceedings of the National Academy of Sciences*, 101: 423-428, 13 January 2004 for a discussion of the potential impact of black carbon on global warming and the uncertainty in estimating the magnitude of that impact.

34 This figure does not include black carbon emissions or emissions leading to the formation of tropospheric ozone. See note 31.

35 See note 3. This range of estimates is based on the range of estimates for various IPCC scenarios, which assume different trajectories for emissions growth.

36 Ibid. Note: some researchers, such as NASA's James Hansen, suggest that ice-sheet breakup could occur more rapidly than the IPCC suggests. See James Hansen, "A Slippery Slope: How Much Global Warming Constitutes 'Dangerous Anthropogenic Interference'?" *Climatic Change* 68:269-279, 2005.

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