Cars and Global Warming

Policy Options to Reduce Maryland's Global Warming Pollution from Cars and Light Trucks

Environment Maryland
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Executive Summary

Maryland could limit its contribution to global warming over the next two decades by implementing policies to reduce carbon dioxide emissions from cars and light trucks. The Clean Cars Program is the best opportunity to reduce vehicle emissions of global warming pollution, and would benefit consumers and the state economy at the same time that it reduces pollution.

Global warming poses a serious threat to Maryland's future.

Scientists project that average temperatures in Maryland could increase by 2° to 9° F over the next century if no action is taken to reduce global warming pollution. Global warming could flood tens of thousands of acres around the Chesapeake Bay, damage water quality in the bay, worsen air quality, and harm Maryland's economy, public health and environment in a host of other ways.

Controlling global warming pollution from the transportation sector—and particularly cars and light trucks—is essential if Maryland is to begin to reduce its emissions and its long-term impact on the climate.

Transportation-related emissions are responsible for approximately 37 percent of Maryland's emissions of carbon dioxide, the leading global warming pollutant. Cars and light trucks—such as pickups, minivans and SUVs—are the most important sources of global warming pollution within the transportation sector, responsible for approximately 70 percent of all emissions from transportation and more than one-quarter of Maryland's total emissions of global warming pollution.

Pollution is increasing rapidly.

Emissions from cars and trucks already have increased by nearly 32 percent from 1990 to 2004 and are projected to rise by an additional 35 percent from 2004 to 2020.

The stagnation in federal corporate average fuel economy (CAFE) standards for cars and light trucks, the recent shift toward greater use of SUVs, and increasing vehicle travel have put Maryland on a course toward dramatically increased emissions of carbon dioxide from transportation over the next two decades.

The Clean Cars Program would greatly reduce pollution.

The Clean Cars Program establishes limits on health-damaging pollution and global warming pollution from automobiles. It will pave the way for the widespread introduction of technologies like hybrid-electric and fuel-cell vehicles, direct-injection engines, advanced transmissions, improved air conditioning systems, and other technologies with the potential to reduce pollution. The program is made up of the Low Emission Vehicle II (LEV II) standards for health-damaging pollution and vehicle global warming pollution standards.

By implementing the program to take effect in model year 2011 (calendar year 2010), Maryland could reduce carbon dioxide pollution from cars and light trucks by 4.4 million metric tons in 2020. This is 14 percent below projected levels. (See Figure ES-1.)

The Clean Cars Program would save consumers money.

One of the central requirements of the vehicle global warming pollution standards is that they be cost-effective. The technological changes needed to achieve the reductions (such as five and six-speed automatic transmissions and improved electrical systems) will likely result in modest increases in vehicle costs that would be more than recouped over time by consumers in the form of reduced fuel expenses.

Cars and the lightest light trucks attaining the 34 percent reduction in global warming pollution required by 2016 would cost an average of $1,064 more for consumers, while heavier light trucks achieving the required 25 percent reduction would cost about $1,029 more. However, these technological changes will significantly reduce operating costs for new vehicles.

For example, a consumer who buys a new car in 2016 will save $20 per month due to lower operating expenses despite the higher cost of the vehicle loan, assuming

Figure ES-1. Estimated Maryland Carbon Dioxide Emissions from Cars and Light Trucks, 2004-2020, Under Policy Scenario

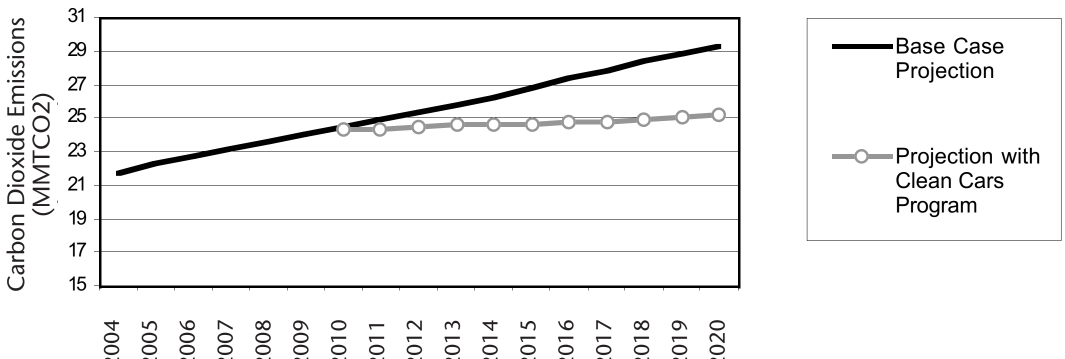


Table ES-1. Net Savings for a Consumer Under Global Warming Pollution Standards in 2016[1]

	Gas Price of $3 per Gallon		Gas Price of $2.20 per Gallon	
	Car	SUV	Car	SUV
Annual Net Savings while Repaying Loan	$245	$320	$115	$170
Annual Net Savings after Loan Is Repaid	$490	$560	$360	$410
Time to Recoup Higher Cost of Vehicle	2.2 years	2.5 years	2.9 years	3.4 years

a gas price of three dollars per gallon. After the loan is paid off, the consumer will save $41 per month. Drivers who purchase a light truck or who pay for the vehicle in cash will experience greater savings. Even at lower gas prices, consumers save money from day one and the accumulated savings exceed the increased purchase price in only a few years. (See Table ES-1.)

The net impact of the standards to the state's economy will be positive, suggesting that Maryland as a whole could save money while at the same time reducing the state's overall emissions of global warming gases.

Introduction

In the past year, Maryland took its first major step toward reducing global warming pollution by joining a regional program to curb emissions from power plants. The Regional Greenhouse Gas Initiative will stabilize emissions from power plants from 2009 to 2015 and then reduce emissions by 10 percent by 2018.

But that's not nearly enough.

To avoid the worst impacts of global warming, climate scientists agree that we need to reduce global warming pollution by about 70-85 percent within the next half-century.

To meet this challenge, the world will need to halt the growth of global warming pollution in this decade, begin reducing emissions soon, and slash emissions dramatically in the coming decades.[2] Because the U.S. is the world's largest global warming polluter, the degree of emission reductions required here will be greater.

The entire path to achieving such pollution reductions isn't yet clear, but the first steps are readily apparent. We should pursue those clearcut policies as quickly as possible.

The Clean Cars Program would likely have an even greater impact on limiting Maryland's contribution to global warming than the Regional Greenhouse Gas Initiative. Since the state has decided it was worth it to take action on power plants, it should be even more willing to do so on vehicles. The program will take little work for the state to implement, and will save money for consumers.

In the long run, we need to develop many innovative approaches to reducing global warming pollution—building carbon-neutral communities, keeping business running with lower transportation needs, transforming the power system to clean energy sources. The roadmap for that action will be difficult to write, but the job will be easier if we act without delay to put the obvious first policies in place.

Adopting the Clean Cars program is the best step that Maryland can take immediately using current technology to reduce its contribution to global warming.

Global Warming and Maryland

Global Warming Impacts to Date

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 kinds of changes 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 Temperatures

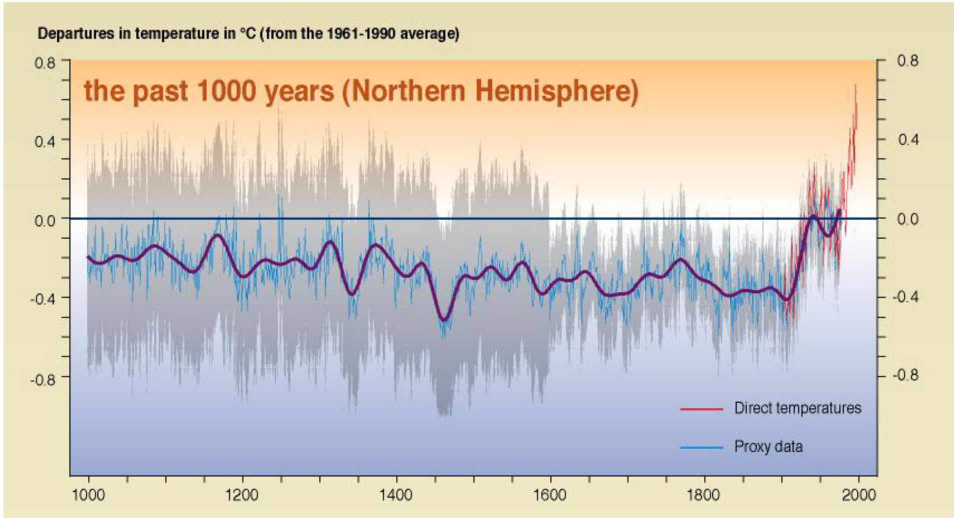
Global average temperatures increased during the 20th century by about 1° F. While this increase may not seem extreme, it is unprecedented in the context of the last 1,000 years of world history.[4] Figure 1 shows temperature trends in the Northern Hemisphere for the past 1,000 years with a relatively recent upward spike.

Global warming appears to have intensified in recent years. In 2006, the National Aeronautics and Space Administration (NASA) reported that, since 1975, temperatures have been increasing at a rate of about 0.36° F per decade.[6] The first six months of 2006 were the hottest such period in the U.S. over more than a century of record-keeping, with temperatures averaging 3.4° F higher than the average for the 20th century, while 2005 was the hottest year on record worldwide.[7] Nineteen of the 20 hottest years ever recorded have occurred since 1983 and nine of the 10 hottest years have occurred since 1995.[8]

In Maryland, the average temperature at the College Park weather station has risen by 2.4° F in the past 100 years.[9] Data from five of eight temperature stations across the state show increasing temperatures from 1948-1999 and increasing temperatures at all stations from 1977-1999.[10] Precipitation in Maryland has increased by 10 percent in many parts of the state.[11]

This warming trend cannot be explained by natural variables—such as solar cycles or volcanic eruptions—but it does correspond to models of climate change based on human influence.[12]

Figure 1. Northern Hemisphere Temperature Trends[5]



Melting Ice

The rise in global temperatures has resulted in thinning ice and decreasing snow cover. Over the last three decades, the volume and extent of ice cover in the Arctic has been declining rapidly, leading to the possibility that the Arctic could be ice-free during the summer by the end of this century.[13] Mountain glaciers around the world have been retreating, and since the late 1960s, Northern Hemisphere snow cover has decreased by 10 percent.[14]

Rising Sea Level

Oceans have risen with the melting of glacial ice and the expansion of the ocean as it warms. Average sea level has risen 0.1 to 0.2 meters in the past century.[15] Sea level rise has already helped cause the inundation of some coastal land. In the Chesapeake Bay, 13 islands have disappeared entirely since the beginning of European settlement four centuries ago.[16] Louisiana loses approximately 24 square miles of wetlands each year, causing an increase in the destructive potential of hurricanes like Hurricane Katrina.[17] While development and land subsidence contribute to the loss of coastal land in these areas, rising sea level also has an impact, and threatens even greater changes in coastal areas in the decades to come.

Sea level near Baltimore has risen seven inches in the past 100 years.[18] Maryland's vulnerability to sea rise is exacerbated by a separate trend: the state is sinking by more than six inches per century as it recovers from glaciers that covered the region thousands of years ago.[19] The net effect of rising sea level and sinking land has been a one-foot increase in water level in the past 100 years. Along Maryland's 3,100 miles of tidally influenced shoreline, 260 acres of land is lost each year.[20] Thirteen islands in the bay have disappeared.[21] Smith Island has lost 30 percent of its land area since 1850. The 1,400-acre Poplar Island has disappeared almost entirely.[22]

More Severe Storms

Storms throughout the middle and high latitudes of the Northern Hemisphere have been getting more intense. The increase in the frequency of heavy precipitation events arises from a number of causes, including changes in atmospheric moisture, thunderstorm activity and large-scale storm activity.[23]

In addition, hurricanes have become more powerful and more destructive over the past three decades, a phenomenon that some researchers link to increasing global temperatures.[24] The number of Category 4 and Category 5 hurricanes globally has nearly doubled worldwide over the past 35 years.[25] And the Atlantic hurricane season of 2005 was the worst ever recorded with the most named storms (28), the most hurricanes (15), the most Category 5 hurricanes (4), the most major hurricanes to hit the U.S. (4), the costliest hurricane (Katrina, which caused more than $80 billion in damage), and three of the six strongest hurricanes recorded (Wilma, the strongest ever, plus Katrina and Rita).[26]

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.[27] That earlier storm, however, caused far less damage, in part because sea level was 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.[28]

Projected Future Impacts of Global Warming

The impacts of global warming are expected to increase in scope and severity in coming years, unless we find a way to quickly reduce our emissions of global warming pollutants.

Global Impacts

Many scientists and policy-makers (such as the European Union) recognize a 2° Celsius (3.6° Fahrenheit) increase in global average temperatures over pre-industrial levels as a rough limit beyond which large-scale, dangerous impacts of global warming would become unavoidable.[29] Even below 2° C, significant impacts from global warming are likely, such as damage to many ecosystems, decreases in crop yields, sea level rise, and the widespread loss of coral reefs.[30]

Beyond 2° C, however, the impacts of global warming become much more severe, including some or all of the following impacts:

- Eventual loss of the Greenland ice sheet, triggering a sea-level rise of 7 meters over the next millennium (and possibly much faster).[31]
- A further increase in the intensity of hurricanes.
- Loss of 97 percent of the world's coral reefs.
- Displacement of tens of millions of people due to sea level rise.
- Total loss of Arctic summer sea ice.
- Expansion of insect-borne disease.
- Greater risk of positive feedback effects – such as the release of methane stored in permafrost – that could lead to even greater warming in the future.[32]

At temperature increases of 3 to 4° C, far more dramatic shifts would take place, including:

- Increased potential for shutdown of the thermohaline circulation, which carries warmth from the tropics to Europe.

- Increased potential for melting of the West Antarctic ice sheet, which in itself could lead to a 5 to 6 meter rise in sea level.
- Major crop failures in many parts of the world.
- Extreme disruptions to ecosystems.[33]

In addition, the more global temperatures rise, the greater the risk that climate change is abrupt and unpredictable. The historical climate record includes many instances in which the world's climate shifted dramatically in the course of decades, even years—with local temperature changes of as much as 10° C in 10 years.[34]

Should the world continue on its current course, with fossil fuel consumption continuing to rise, temperature increases of well above 2° C are likely to occur. The Intergovernmental Panel on Climate Change, in its 2001 Third Assessment Report, laid out a scenario in which population, economic output and fossil fuel consumption continue to grow dramatically. Under that scenario, the concentration of carbon dioxide in the atmosphere in 2100 would be nearly three-and-a-half times its preindustrial level, global average temperatures by the end of the century would be 4.5° C higher than in 1990, and temperatures would continue to rise for generations to come.[35]

Maryland Impacts

Global warming will have consequences for both rural and urban areas in Maryland.

Maryland's climate is expected to grow warmer, with spring temperatures rising by 1° F to 7° F by 2100.[36] 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, ocean level is expected to be another 19 inches higher.[37] Statewide, an estimated 380,000 acres of land are less than five feet above sea level and are vulnerable to inundation during high tides or to complete submersion.[38] Wicomico, Somerset and Dorchester counties are most at risk. By one estimate, shorelines in those counties could migrate inland by three to six miles.[39]

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 levels, meaning that wetlands on the ocean side of those barriers will not be able to migrate inland.[40]

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 very difficult to sell affected homes.[41]

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 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.[42] The problem will grow worse as water temperatures rise, because warmer water cannot retain oxygen as easily.

Increased precipitation would change the bay's salinity, which can affect the migratory patterns of fish and crabs. Too much freshwater in the bay can kill oysters. On the other hand, sea level rise could instead make the bay saltier—under these conditions, oyster diseases may spread more readily.[43]

Increasing water temperatures in the bay and its tributaries will also have detrimental effects. Late last summer, high water temperatures were blamed for the widespread die-off of eelgrass in the middle and lower parts of the bay. Sustained temperature increases could devastate this critical habitat and affect the juvenile crabs and finfish that use it for shelter.[44]

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.[45]

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 level may cause a decline in bird populations.[46] Food supplies may dwindle as algal blooms, increased water temperature, and depleted oxygen levels impair the growth of the aquatic plants and animals that are an important food source for many waterfowl.[47]

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.[48] Smaller wildlife populations 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.[49] 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.[50]

The incidence of insect-borne disease may rise also, as mosquito and tick populations thrive in warm, wet weather.[51] 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.[52]

Human Activities Are Causing Global Warming

Many of the changes described above are consistent with the kinds of climatic shifts scientists believe will occur as a result of global warming. They are also signs that human activities have begun to affect the climate through the release of pollutants (known as greenhouse gases or global warming pollutants) that exacerbate the earth's natural greenhouse effect.

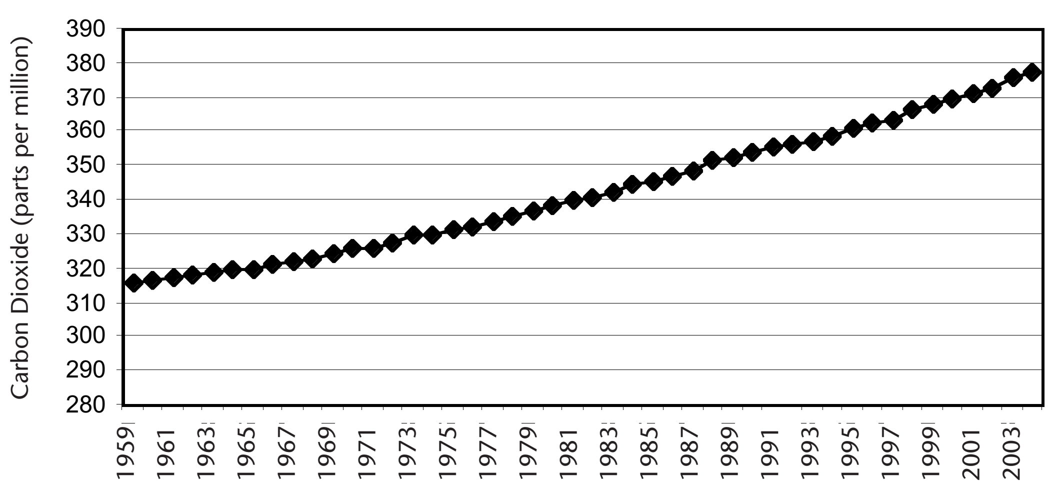
The Greenhouse Effect

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, trap radiation from the sun near the planet's surface. 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.

But human activities, particularly over the last century, have altered the composition of the atmosphere in ways that intensify the greenhouse effect.

Since 1750, for example, the concentration of carbon dioxide (the leading global warming pollutant) in the atmosphere has increased by 35 percent as a result of human activity.[53] (See Figure 2.) The current rate of increase in carbon dioxide concentration is unprecedented in the last 20,000 years.[54] Figure 2 shows increases in carbon dioxide concentrations for the past 45 years. Concentrations of other global warming pollutants have increased as well.

Figure 2. Increases in Recorded Carbon Dioxide Concentrations, 1959-2004[55]

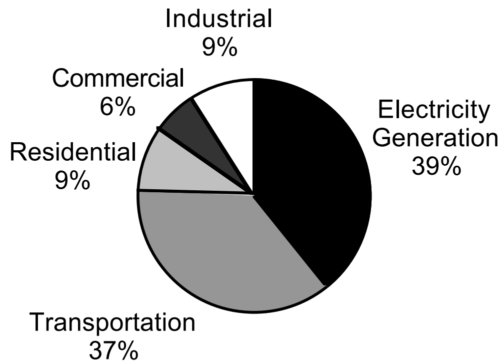


Global Warming Pollution in Maryland

Carbon dioxide emitted from fossil fuel use is the leading cause of global warming. In 2004, fossil fuel use in Maryland resulted in the release of 77.4 million metric tons of carbon dioxide ($MMTCO_2$, see note on units next page).

The transportation sector is responsible for approximately 37 percent of Maryland's releases of carbon dioxide.[56] (See Figure 3.) Cars and light trucks—such as pickups, minivans and SUVs—are the most important sources of global

Figure 3. Maryland Sources of Global Warming Emissions in 2004[58]



Other Global Warming Pollutants

This report focuses on transportation-related emissions of carbon dioxide—the leading pollutant responsible for global warming and the global warming gas released in the largest quantities by cars and trucks. Cars and trucks produce other global warming pollution, however, that must be considered in any emission reduction strategy.

- **Methane** – Methane gas is likely the second most important contributor to global warming. Cars and light trucks produce methane in their exhaust, but it is thought that they are only minor emitters of methane and that pollution will be reduced in the future through improved emission control systems.[59]
- **Nitrous Oxide** – Nitrous oxide is also produced in automobile exhaust, with mobile sources estimated to contribute about 13 percent of U.S. nitrous oxide emissions in 2002.[60] As with methane emissions, improved pollution control measures may reduce nitrous oxide emissions in the future.
- **Hydrofluorocarbons (HFCs)** – HFCs are extremely potent global warming gases, yet tend to be released in only very small quantities. HFCs are often used as coolants in vehicle air conditioning systems and can escape from those systems into the environment.
- **Black carbon** – Black carbon, otherwise known as "soot," is a product of the burning of fossil fuels, including diesel fuel used in heavy-duty trucks and a small percentage of light-duty vehicles. Recent research has suggested that, because black carbon absorbs sunlight in the atmosphere and on snow and icepack, 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 pollution contributes to global warming.[61]

A Note on Units

Because various gases contribute to global warming, and the potency of the warming effects of those gases varies, inventories of global warming pollution typically use units that communicate emissions in terms of their global warming potential.

In this report, we are measuring emissions of carbon dioxide only and thus report emissions in terms of carbon dioxide. Other documents may communicate pollution in terms of "carbon equivalent." To translate carbon equivalent to carbon dioxide, one can simply multiply by 3.66.

warming pollution within the transportation sector, responsible for approximately 70 percent of all transportation-sector emissions and more than one-quarter of Maryland's total emissions of global warming pollution.[57]

Pollution Reduction Efforts in Maryland

Maryland has already taken several steps to begin reducing its global warming emissions. In 2004, the state adopted efficiency standards for nine common residential and commercial appliances, standards that were later adopted at the federal level.[62] That same year, Maryland enacted a requirement that 7.5 percent of the state's electricity come from clean renewable resources by 2019.[63] Both of these measures should reduce the amount of carbon-intensive electricity consumed in the state. Maryland joined the Regional Greenhouse Gas Initiative (RGGI) earlier this year, an agreement among eight northeastern states to reduce global warming pollution from power plants by 10 percent by 2018. The full details of the agreement have not yet been established. Actual savings will depend on how strongly the state implements the program.

While these standards will help to reduce Maryland's global warming pollution, they touch only some of the sectors that produce global warming emissions. One of the major sectors not covered is transportation. Maryland will need to do more to reduce emissions from those sectors, as well as begin to address the challenge of emissions from the transportation sector.

The Transportation Challenge

The challenge of reducing global warming pollution from cars and trucks is formidable, and growing increasingly so with each passing year.

Three trends in the transportation sector—increasing vehicle miles traveled, stagnating fuel economy, and increasing numbers of light trucks and SUVs—make the challenge of reducing global warming pollution in Maryland even greater.

Increasing Vehicle Miles Traveled

Maryland residents are traveling more miles in their cars and light trucks than ever before. Between 1995 and 2005, the number of vehicle-miles traveled (VMT) annually on Maryland's roads increased from 44.9 billion miles to 56.7 billion miles—an increase of 26 percent.[64] (See Figure 4.) If VMT growth continues at the same rate, by 2020, VMT will increase 41 percent to 79.8 billion miles. Given the population increase that will accompany the recent reassignment of military personnel from other states to Maryland, this increase in VMT is likely to be a low-end estimate of business-as-usual projections.

Stagnating Fuel Economy

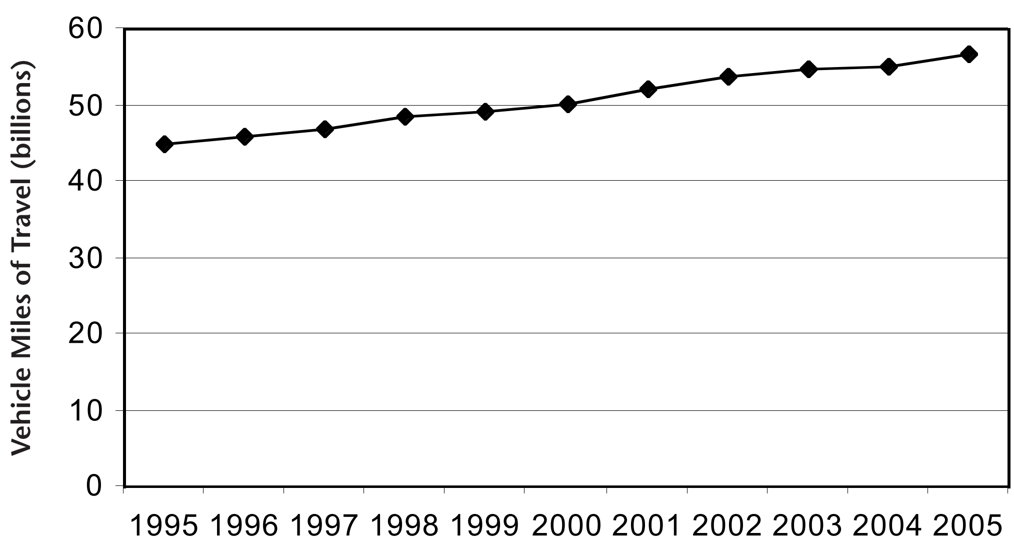
The imposition of federal Corporate Average Fuel Economy (CAFE) standards beginning in 1975 led to dramatic improvements in the fuel efficiency of American cars and light-duty trucks. The CAFE standards required a gradual increase in fuel economy during the 1970s and 1980s, topping out at an average fuel economy for new cars of 27.5 miles per gallon (mpg) by 1990 and 20.7 mpg for light trucks by 1996.[66] (The National Highway Traffic Safety Administration has begun to phase in an increase in the light truck standard to 22.2 mpg, to be fully achieved by model year 2007.)

In the decade-and-a-half following enactment of the CAFE standards, the "real world"[67] fuel economy of passenger cars nearly doubled—from 13.4 mpg in 1975 to 24.0 mpg in 1988. Similarly, light trucks experienced an increase in real-world fuel economy from 11.8 mpg in 1975 to 18.3 mpg in 1987.[68]

However, the trend in the 1990s was toward less fuel-efficient vehicles. Though fuel economy has stabilized for the past several years, in many cases Americans get fewer miles per gallon from their new vehicles today than they did during the Reagan administration.

Until recently, the federal government had failed to increase CAFE standards for more than a decade. To make matters worse, changes in driving patterns, including higher speeds and increased urban driving, have led to a real-world decrease in fuel economy. An EPA analysis of fuel economy trends found that the

Figure 4. Maryland VMT Increased 26 Percent between 1995 and 2005[65]



average real-world fuel economy of light-duty vehicles sold in 2003 was lower than the average fuel economy of vehicles sold in 1981. Indeed, the average real-world fuel economy of new cars and light trucks actually *declined* by 7 percent between 1988 and 2003.[69] (See Figure 5.) Combined average real-world fuel economy started at 13 mpg in 1975, rose to 21.8 in 1988, and then dropped to 20.3 in 2003.

Amid growing public pressure to improve vehicle fuel economy, the U.S. Department of Transportation is increasing CAFE standards for light trucks by a modest 1.5 mpg between 2005 and 2007. While this action does not go far enough to take advantage of many technologies that could cost-effectively improve fuel economy, even a modest increase in CAFE standards has some effect in reducing the rate of growth of transportation carbon dioxide pollution.

Growing Numbers of SUVs and Light Trucks

While the fuel economy of the average car and light truck has stagnated over the past two decades, the average fuel economy of the entire new-car fleet has declined—thanks to the dramatic shift toward sport utility vehicles (SUVs), vans and light trucks.

In 1975, when the first federal CAFE standards were enacted, SUVs made up 2 percent of the light-duty vehicle market, vans 5 percent, and pickup trucks 13 percent. By model year 2004, however, SUVs accounted for 26 percent of light-duty vehicle sales, vans 7 percent, and pickup trucks 15 percent. The light-duty market share of passenger cars and station wagons dropped over the same period from 81 percent to 52 percent.[71] (See Figure 6.)

This shift toward larger vehicles has caused the average fuel economy of the entire new light-duty vehicle fleet to dip as low as 20.4 mpg in 2001—lower than at any time since 1980 and down by nearly 8 percent from the historical peak in 1987 and 1988.[72]

The trend toward SUVs and light trucks could continue, with light trucks making up an increasing percentage of the entire light-duty fleet as time goes on. The Environmental Protection Agency projects that by 2020, 64 percent of all light-duty vehicles on the road will be light trucks.[73] Recent increases in gasoline

Figure 5. Average Fuel Economy for New Light-Duty Vehicle Fleet on the Decline[70]

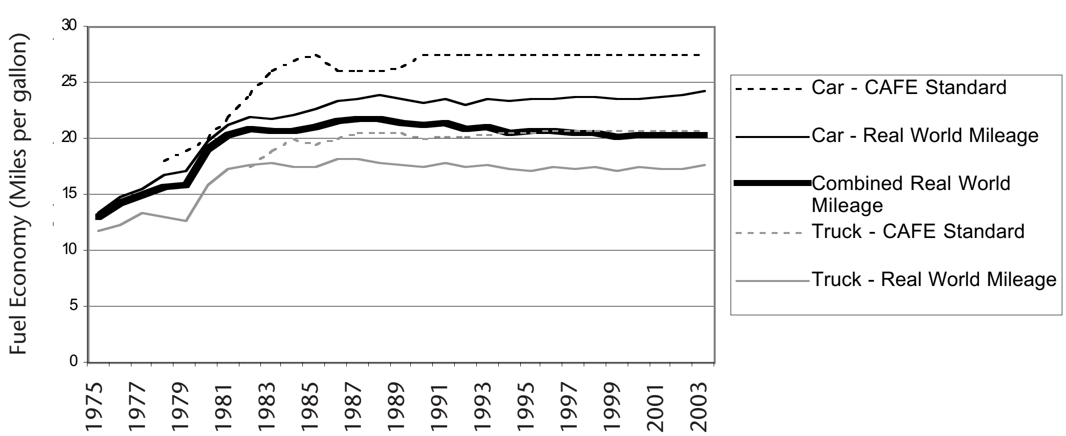
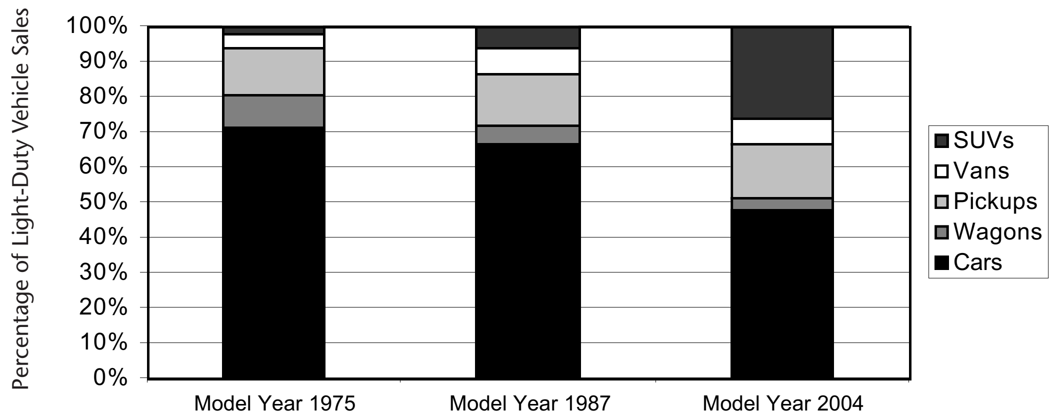


Figure 6. Light-Duty Vehicle Mix Shifts from Cars to Trucks, Vans and SUVs



prices have slowed sales of SUVs, but it is too early to determine if the long-term shift toward SUVs and light trucks will change significantly.

Recently, manufacturers have promoted "cross-over" vehicles as an alternative to SUVs. These are vehicles that look like large station wagons but are categorized as SUVs. Because cross-over vehicles are subject to light truck emission standards, their fuel economy is often no better than that of conventional SUVs.

The combination of these three factors—more miles traveled, increasingly in trucks and SUVs, with stagnant fuel economy across the entire vehicle fleet—poses a great challenge to Maryland policy-makers as they attempt to reduce global warming pollution from the transportation sector.

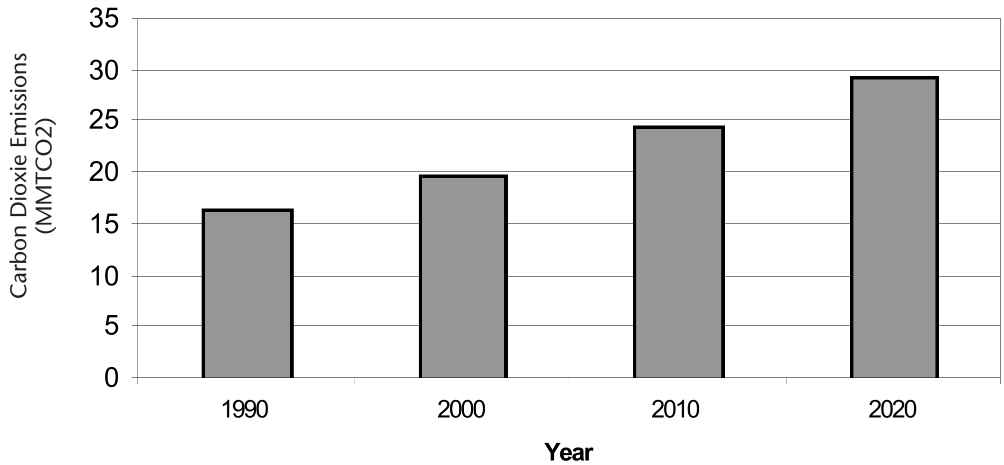
Vehicle Carbon Dioxide Pollution in Maryland: Past and Projected

Based on Maryland-specific fuel consumption data compiled by the U.S. Energy Information Administration (EIA), cars and light-duty trucks released approximately 16.5 million metric tons of carbon dioxide into the atmosphere in 1990. By 2004, those emissions had increased by 32 percent, to 21.7 $MMTCO_2$, and cars and trucks were responsible for 28 percent of Maryland's emissions of global warming pollution.

Any attempt to project Maryland's future global warming pollution depends greatly on the assumptions used. The "Assumptions and Methodology" section at the conclusion of this report describes in detail the assumptions used to develop the following projections. Simply put, the "base case" for carbon dioxide emissions (based largely on data and projections by state and federal government agencies) assumes continued growth in vehicle travel, slight improvement in vehicle fuel economy, and a continuation of the trend toward increased purchases of sport utility vehicles and other light trucks.

Based on these assumptions, carbon dioxide emissions from the Maryland light-duty vehicle fleet are projected to increase 12 percent over 2004 levels by 2010, followed by a further 20 percent increase between 2010 and 2020. In other words, by 2020, carbon dioxide emissions from cars and light trucks could be 78

Figure 7. Actual and Projected Carbon Dioxide Emissions from Light-Duty Vehicles in Maryland, 1990-2020



Transportation and Global Warming: A Primer

A gallon of gasoline contains a set amount of carbon, nearly all of which is released to the atmosphere when it is burned. Some of the carbon is released in the form of hydrocarbons; most of it is released in the form of carbon dioxide. For each gallon of gasoline burned in a vehicle, about 19.6 pounds of carbon dioxide is released to the atmosphere. In addition, the consumption of gasoline creates significant additional "upstream" emissions of carbon dioxide resulting from the extraction, transportation, refining and distribution of the fuel. Other fuels have greater or smaller amounts of carbon in a gallon (or its equivalent).

Unlike other vehicular air pollutants that result from the incomplete combustion of fossil fuels or from fuel impurities, carbon dioxide is a natural result of the combustion process. As a result, there are three main ways to limit carbon dioxide pollution from motor vehicles:

1. Drive more efficient vehicles.
2. Reduce the number of miles traveled.
3. Switch to fuels with a lower carbon content, such as biofuels containing ethanol.

Vehicles also emit smaller amounts of other global warming gases, such as methane and nitrous oxide, as well as hydrofluorocarbons from the use of the air conditioning system. Control of some of these emissions is possible through means other than reducing fuel use or substituting low-carbon fuels.

percent greater than 1990 levels in the absence of action to reduce emissions. (See Figure 7.)

An increase of such magnitude would severely challenge Maryland's ability to stabilize and eventually reduce global warming pollution from the transportation sector and the state as a whole. Should these increases in emissions from cars and light trucks occur, Maryland would need to achieve dramatic reductions in global warming pollution from other sectors of the state's economy in order to achieve long-term reductions of 70 to 85 percent, a level of reduction estimated by scientists as necessary to limit any dangerous threat to the climate.[74]

However, this path toward increasing carbon dioxide pollution from cars and light trucks is not inevitable. Public policies that require or encourage the purchase of more fuel-efficient or advanced technology cars can make a significant dent in Maryland's future emissions of global warming pollution while potentially saving money for drivers. One of the most powerful policy options is setting limits on vehicle global warming pollution.

Tools to Reduce Global Warming Pollution from Cars and Light Trucks

Maryland has many potential tools available to reduce emissions of global warming pollution from the transportation sector. In addition to greater efforts to promote alternatives to driving, the state should use one of the most powerful tools it has available: global warming pollution standards for cars and trucks.

The Clean Air Act gives states two options for control of motor vehicle emissions identified as pollutants under the Act. States may choose to comply with federal emission standards or adopt the more protective standards—known as the Clean Cars Program—developed by the state of California, the only state empowered by the Clean Air Act to devise its own emission regulations.

Ten states—New Jersey, New York, Massachusetts, Connecticut, Rhode Island, Vermont, Maine, Oregon, Washington and California—have adopted the Clean Cars Program, including the vehicle global warming emission standards. Several other states are actively considering it.

As discussed below, adoption of the Clean Cars Program would significantly reduce emissions of global warming gases from cars and trucks, providing important assistance in Maryland's efforts to curb global warming pollution.

The Clean Cars Program has two parts, analyzed separately below. The first component of the Clean Cars Program, the Low-Emission Vehicle II (LEV II) standards, promotes advanced-technology vehicles and would provide a first step in reducing greenhouse gas pollution. The second part of the program targets global warming pollution directly.

LEV II Standards

The LEV II standards seek to reduce emissions of smog-forming and other hazardous pollutants. They achieve this by establishing fleet-wide limits on tailpipe emissions and by requiring the sale of advanced-technology vehicles such as hybrids that have even lower emissions.

By adopting the program, Maryland can expect to have increasing percentages of advanced-technology vehicles on the road over the next decade and more.

Some of the technological changes encouraged by LEV II will reduce emissions of global warming pollutants. LEV II promotes advanced technology vehicles in three ways, as described below.

Pure Zero-Emission Vehicles

"Pure" zero-emission vehicles (pure ZEVs) are those—like battery-electric and fuel-cell vehicles—that release no toxic or smog-forming pollutants from their tailpipes or fuel systems. They also have the potential to release far fewer global warming gases than today's vehicles. (Note, however, that fuel-cell vehicles have zero emissions only when the electricity used to create the hydrogen is generated from renewable sources.)

The most recent revision to LEV II's advanced technology program shifted the emphasis from near-term deployment of battery-electric vehicles to the long-term development of hydrogen fuel-cell vehicles. As a result, automakers will not have to sell fuel-cell or other pure zero-emission vehicles in Maryland until at least model year 2012. Even then, the number of pure ZEVs required for sale in Maryland would be small, representing less than one percent of new car and light truck sales until model year 2016.[75]

In addition, the California Air Resources Board (CARB), which administers the program in California, has convened a panel of experts to review the status of fuel-cell technology prior to the agency enforcing any pure ZEV requirements for the 2009 model year and beyond.[76] After reviewing the panel's conclusion, CARB staff may make a recommendation to modify the advanced technology program's requirements for pure ZEVs, particularly if it seems that ZEVs are not yet ready for widespread commercial release. Every revision CARB has made to the program in the past has been to increase flexibility for automakers.

The current LEV II standard, therefore, requires the sale of very few pure zero-emission vehicles over the next decade. But it does provide an incentive for automakers to continue research and development work on technologies such as hydrogen fuel-cell vehicles that could provide zero-emission transportation in the future.

Partial Zero-Emission Vehicle (PZEV) Credits

The majority of vehicles that automakers produce to comply with the advanced technology program will be vehicles that receive "partial ZEV credit"—otherwise known as "PZEVs." PZEVs are conventional gasoline vehicles in every way but one: they are engineered to produce dramatically lower emissions of air toxics and smog-forming pollutants.

While PZEVs will play an important role in helping Maryland to achieve its air quality goals, the technologies used in PZEVs do not necessarily make a substantial contribution to reducing global warming pollution from cars. Thus, we do not assume any global warming benefits from the PZEV portion of the program.

Advanced Technology PZEVs (AT-PZEVs)

The greatest near-term global warming impact of the advanced technology program will likely come from provisions to encourage the sale of PZEVs that either run on a cleaner alternative fuel, such as compressed natural gas, or that use advanced technologies, such as hybrid-electric drive. These are known as "advanced technology PZEVs" or "AT-PZEVs."

To encourage automakers to release additional new hybrid vehicles as early as possible, automakers are allowed to comply with part of their sales obligations in the early years of the program through the sale of AT-PZEVs. Automakers have flexibility on how much they want to use this compliance path. The most likely scenario would result in hybrids constituting six percent of new car sales in 2010, increasing to ten percent by 2014.

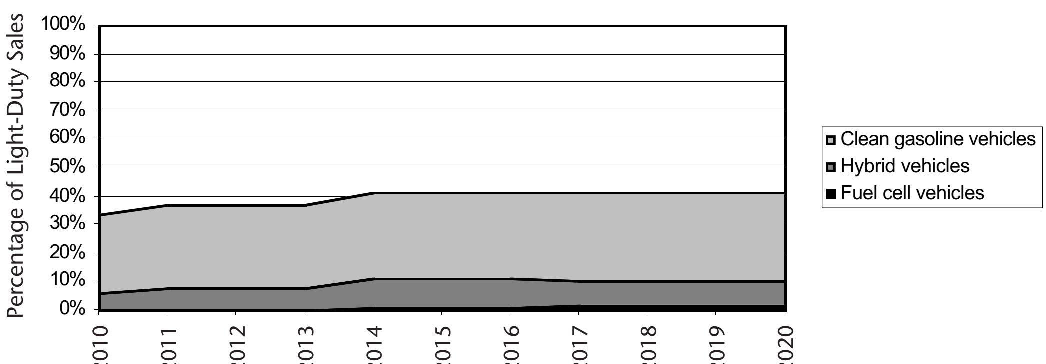
Hybrid-electric vehicles are the most likely technology to be used to comply with AT-PZEV standards. Hybrids have proven to be very popular with consumers, especially in an era of higher and rapidly fluctuating gasoline prices. Sales of hybrid vehicles have increased steadily since their introduction to the domestic market in December 1999. About 212,000 hybrids were sold in the U.S. in 2005, a 250 percent increase over sales in 2004.[77]

Thus far, seven models of vehicles have been certified to AT-PZEV emission standards: the Toyota Prius, the Honda Civic hybrid and Accord hybrid, the Ford Escape hybrid, the Mercury Mariner hybrid, the Mazda Tribute hybrid, and the natural gas-powered Honda Civic GX.[78] (Several other hybrid vehicles, such as the Toyota Camry, are on the market but either their emissions are too high to meet AT-PZEV standards or the automaker does not want to offer the extended warranty required with PZEVs. These vehicles nonetheless can achieve measurable reductions in global warming emissions.)

Unfortunately, although a healthy market for hybrids appears to exist, automakers have not yet supplied hybrids in large enough quantities to meet consumer demand. The demand crunch could ease slightly if automakers introduce additional hybrid models as planned—including hybrid versions of the Nissan Altima and Toyota Sienna—that could qualify for AT-PZEV credit.[79] The planned increase in hybrid models comes largely as a strategy to comply with standards in states that have adopted the Clean Cars Program. Future availability of these hybrids in other states is highly uncertain.

Should automakers choose to maximize their use of AT-PZEVs to comply with the advanced technology program in Maryland—and do so using vehicles similar to the Toyota Prius—hybrids could make up about 6.3 percent of the state's car and light truck sales in 2010, increasing to 10.1 percent by 2014. (See Figure 8.) This translates to sales of about 20,000 hybrids in Maryland in 2010, increasing to approximately 31,000 annually by 2016. Because the advanced technology program offers a great deal of flexibility, however, automakers could choose to comply by manufacturing greater numbers of less-advanced hybrids or smaller numbers of pure ZEVs, among other options.

Figure 8. Percentage of Light-Duty Vehicle Sales in Maryland with Adoption of Clean Cars Program, 2010 through 2020



Also unclear is the degree of global warming gas reductions that can be expected from vehicles complying with AT-PZEV standards. Hybrid-electric vehicles and alternative-fuel vehicles vary greatly in their emissions of global warming pollution. Some, like the Toyota Prius, offer great reductions in global warming emissions. Others, such as hybrid pickup trucks to be sold by General Motors and DaimlerChrysler, continue to have significant global warming pollution despite their improved emissions compared to conventional models. The LEV II program does provide additional credit to hybrid-electric vehicles that attain a greater share of their power from an electric motor, which generally allows them to achieve lower carbon dioxide emissions. For the purposes of this analysis, we assume that hybrids manufactured to comply with AT-PZEV standards will release about 30 percent fewer global warming gases per mile than conventional vehicles.[80]

LEV II Program Impacts: Long Term

On the front end, no assessment of short-term global warming pollution reductions can precisely capture the potential long-term and indirect benefits of the LEV II program in reducing carbon dioxide emissions. At its heart, the program is a "technology forcing" program—one that attempts to jump-start advanced technology vehicle development and the adoption of these technologies in the mainstream auto market. That being said, however, adoption of the program will likely bring about significant long-term pollution reductions as technological changes brought about by the program spread to other vehicles in the Maryland car and truck fleet.

An example of the potential power of the program to hasten technological change is the development of hybrid vehicles in the 1990s. Adoption of the original LEV program sparked public and private-sector research efforts into the development of advanced batteries and electric-drive technologies. While the generation of full-function electric vehicles that resulted from that research—such as Honda's EV-Plus and General Motors's EV1—were not sold in large quantities, the research effort drove advances in electric vehicle technology that facilitated the birth of the popular hybrid-electric systems that now power hundreds of thousands of vehicles worldwide and have laid the groundwork for recent advances in fuel-cell vehicle technology.[81]

Similarly, the current form of the LEV II program is designed to encourage continued investment in hybrid-electric and hydrogen fuel-cell vehicle development and may lead to the development of new types of vehicles (such as "plug-in hybrids" that combine the benefits of battery-electric and hybrid-electric vehicles) with significant benefits for the climate. Once developed and offered to consumers, it is possible that these vehicles could come to represent a far greater share of the new car market than is estimated here.

LEV II Program Impacts: Short Term

The short-term impact of the LEV II program on carbon dioxide emissions in Maryland will largely be determined by how automakers choose to comply with the program's flexible provisions. There are almost infinite options available to automakers for compliance—however, it is likely that one or several technologies will dominate the mix of vehicles certified under the program.

We assume that automakers will take maximum advantage of the ability to meet ZEV requirements with PZEVs and AT-PZEVs. We also assume that vehicles sold to meet AT-PZEV requirements are hybrid-electric vehicles with technological characteristics similar to the Toyota Prius. We assume that any vehicles sold to meet pure ZEV requirements are hydrogen fuel-cell vehicles whose fuel is generated from natural gas. And we use conservative assumptions about the carbon dioxide emission reductions that could result from hybrid or fuel-cell vehicles.

Vehicle Global Warming Pollution Standards

In July 2002, California adopted the first law to control carbon dioxide emissions from automobiles. Beginning in model year 2009, automakers will have to adhere to fleet average emission limits for carbon dioxide similar to current limits on smog-forming and other pollutants. Emissions of global warming pollution will fall and consumers will save money.

The standards require CARB to propose limits that "achieve the maximum feasible and cost effective reduction 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 cannot be imposed to attain the new standards.[82] In September 2004, CARB adopted rules for implementation of the global warming pollution standards. Those proposed rules provided the basis of our analysis here.

> With the Clean Cars Program, a consumer who buys a new car in 2016 would save $20 per month due to lower operating expenses despite higher loan costs.

In developing the global warming pollution standards, the CARB staff reviewed several analyses of the types of technologies that could be used to achieve "maximum feasible and cost effective" reductions in global warming pollution from vehicles. CARB's proposal estimates that near-term technologies could reduce average global warming pollution from cars and the lightest light trucks by 25 percent and from heavier light trucks by 18 percent. Over the medium term (2013 to 2016), cost-effective reductions of 34 percent for cars and smaller light trucks and 25 percent for heavier light trucks are feasible.[83]

One of the central requirements of the standards is that they be cost-effective. CARB has adhered to that requirement and added a margin of error to ensure that the standards meet that requirement. Early analysis by CARB suggested that deeper cuts in vehicle emissions could be made more quickly than were ultimately incorporated into the standard. CARB's initial draft proposal for implementation of the standards called for cost-effective emission reductions of 22 percent from cars and 24 percent from light trucks in the near term. Over the medium term (2012 to 2014), cost-effective reductions of 32 percent for cars and 30 percent for light-trucks were deemed feasible. In addition, the standards were assumed to be phased in much more quickly than under CARB's most recent proposal.[84]

The technological changes needed to achieve the reductions that CARB did require (such as five and six-speed automatic transmissions and improved electrical systems) will likely result in modest increases in vehicle costs that would be more than recouped over time by consumers in the form of reduced fuel expenses. CARB projects that cars and the

Table 1. Net Savings for a Consumer Under Global Warming Pollution Standards in 2016[88]

	Gas Price of $3 per Gallon		Gas Price of $2.20 per Gallon	
	Car	SUV	Car	SUV
Annual Net Savings while Repaying Loan	$245	$320	$115	$170
Annual Net Savings after Loan Is Repaid	$490	$560	$360	$410
Time to Recoup Higher Cost of Vehicle	2.2 years	2.5 years	2.9 years	3.4 years

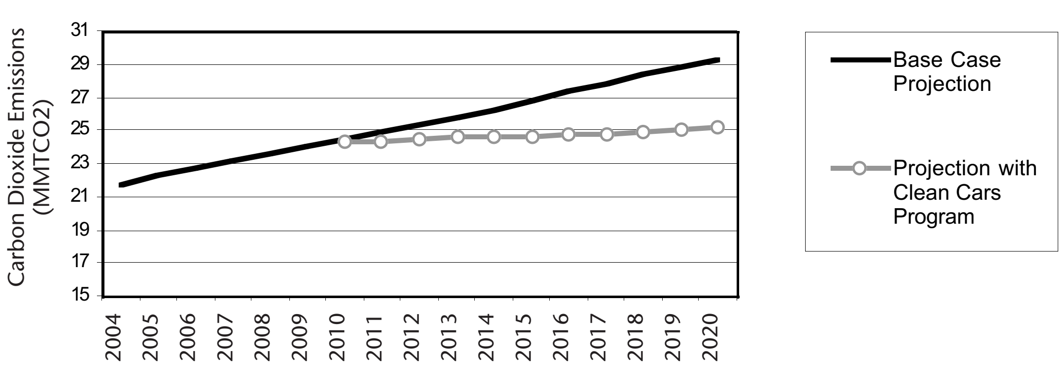
lightest light trucks attaining the 34 percent reduction in global warming pollution required by 2016 would cost an average of $1,064 more for consumers, while heavier light trucks achieving the required 25 percent reduction would cost about $1,029 more.[85]

However, the agency also estimates that the rules will significantly reduce operating costs for new vehicles. Though consumers will face higher monthly loan payments when purchasing vehicles that comply with the standards, those increased costs will be more than offset by lower operating expenses.

For example, a consumer who buys a new car in 2016 will save $20 per month due to lower operating expenses despite higher loan costs, assuming a gas price of three dollars per gallon. After the loan is paid off, the consumer will save $41 per month. Drivers who purchase a light truck or who pay for the vehicle in cash will experience greater savings. Even at lower gas prices, consumers save money from day one and the accumulated savings exceed the increased purchase price in only a few years.[86] (See Table 1.)

CARB also projects that the net impact of the standards to the state's economy will be positive, suggesting that Maryland as a whole could save money while at the

Figure 9. Reductions in Carbon Dioxide Emissions Under Global Warming Pollution Standards (Light-Duty Vehicles)



same time reducing the state's overall emissions of global warming gases.[87]

Assuming that Maryland adopts the standards beginning with the 2011 model year, the resulting reductions in global warming pollution would be significant. Compared to the base case projection, the emission standards would reduce light-duty carbon dioxide emissions by 14.1 percent by 2020—for a total reduction of 4.4 $MMTCO_2$. (See Figure 9.)

The emission standards would reduce carbon dioxide emissions from light-duty vehicles by 14.1 percent in 2020—a reduction of 4.4 million tons per year from business-as-usual projections.

Adopting the Clean Cars Program can contribute significantly to efforts to reduce global warming pollution from Maryland's transportation sector. With both components in effect, emissions from light-duty cars and trucks would be 16 percent greater in 2020 than they were in 2004, compared to 35 percent greater if no action is taken. From 2010 to 2020, adoption of the Clean Cars Program will limit the increase in emission from cars and light trucks to just 3 percent.

Policy Recommendations

Attaining reductions in carbon dioxide emissions will require significant actions to reduce emissions from light-duty vehicles. No one policy will solve the problem. The Clean Cars Program is the best single policy, and comes at a net financial gain to the state, but Maryland will need to pursue a range of policies.

Reduce Per-Mile Emissions from Vehicles

Adopt the Clean Cars Program

The first step Maryland should take is to adopt the Clean Cars Program for implementation in model year 2011, establishing vehicle global warming pollution standards. The standards will greatly reduce emissions from light-duty vehicles from projected levels. The analysis throughout this report testifies to the importance of the Clean Cars Program.

Encourage the Purchase of Lower-Carbon Vehicles

The state should create incentives for individuals and fleets to purchase vehicles with lower carbon emissions. One possible approach is to offer incentives that would give a rebate to car buyers who purchase vehicles that emit less global warming pollution. In addition to hybrid cars, any vehicle that offers below-average global warming emissions potentially could qualify (provided that emissions of other pollutants, such as diesel particulate matter, do not contribute to air quality problems). The rebate could be funded by a fee on purchasers of less efficient vehicles and thus could be revenue neutral for the state. Connecticut and several other New England states are considering such a program.[89]

Another option would be to offer a state tax credit for the purchase of hybrids that meet standards for low emissions of global warming pollution.

State and local governments should purchase lower carbon emission vehicles for their fleets. This could be accomplished by buying vehicles that have the lowest emissions in their class and by purchasing the lowest-emitting vehicle that can satisfy the intended purpose.

Promote Biofuels

Biofuels are typically made from such crops as corn, soybeans, canola, rapeseed, or mustard seed. The global warming impact of biofuels can be much lower than petroleum fuels, especially if they are created from specialized energy crops such as switchgrass. Crops temporarily remove carbon from the atmosphere as they grow and return it when they decay or are burned.[90] Burning fossil fuels releases carbon that had been removed from the atmosphere thousands of years ago.

Renewable fuels typically are mixed with petroleum-based fuels, such as gasoline or diesel. All vehicles are capable of using fuel with a small percentage of biofuel. Vehicles can be configured to run on higher percentages of biofuel and thus provide greater global warming pollution advantages. A statewide renewable fuel standard can be structured either to require some amount of renewable fuel in all vehicle fuel sold in Maryland, or to require that a percentage of all fuel sold in the state consist of renewable content. Maryland could begin with a requirement that 10 percent of gasoline consist of ethanol and that 5 percent of diesel fuel consist of biodiesel. The state should promote fuels that provide the greatest global warming benefit and that will not adversely affect air quality or the environment.

A number of other states have successfully implemented similar renewable fuels standards. Minnesota recently began to require that all diesel contain at least 2 percent biodiesel, and many states—such as California, Colorado, New York, Iowa and several other Midwestern states—now use ethanol as an oxygenate in gasoline.

Reduce Growth in Vehicle Travel

Improve Transit Service

Better bus and rail service could reduce the amount citizens need to drive. Existing bus service could be improved with more frequent service and extended hours. In relatively low density neighborhoods and shopping areas, small shuttle buses can carry passengers to major bus lines that are beyond walking distance. Smaller cities and towns that do not have transit should establish bus service. Carpools and vanpools can help serve areas not accessible to transit.

Rail transit options need to be expanded. In the Baltimore area, a comprehensive light-rail network could carry commuters and visitors from residential areas around the city to major destinations. Building the Purple Line would link Bethesda, Silver Spring, College Park and New Carrollton by rail, reducing the need to drive.

Reduce Commuting

Employers can help organize and promote ride-sharing programs by pairing drivers with similar commutes, offering preferred parking to carpools, and providing a ride home if an employee has a mid-day emergency or needs to stay at work late.

Employers can also encourage and provide the infrastructure for telecommuting. Assistance installing telecommunications equipment in a home combined with allowing staff to work from home for part of the week can raise an employee's overall productivity and reduce commuting at the same time.

Expand Walking and Biking Options

Many trips can be completed on foot or

bicycle instead of in a car, but the lack of safe routes for walking or cycling deters people. Sidewalks with pedestrian amenities such as benches and trees, and shops oriented toward customers on foot rather than in cars can encourage more people to walk. Changes to road design can slow traffic, making it easier and safer for pedestrians and cyclists to cross busy intersections.

Link Insurance to Miles Driven

For almost all drivers, insurance is a "fixed cost," meaning that they pay the same amount each year regardless of how much they drive. As a result, when drivers consider the cost of driving extra miles, insurance expenses do not come into play. Offering insurance on a cents-per-mile basis can encourage car owners to drive less by making apparent the full costs of each mile driven.

Private insurers could offer cents-per-mile insurance that allows drivers to purchase insurance by the mile. Drivers would have a direct financial incentive to drive less. Such insurance also can provide a benefit to senior citizens and others who drive less than average.

Promote Smart Growth

Compact development can reduce how much people need to drive. Many existing developments in Maryland are spread out, placing jobs and shops out of easy walking distance of homes. New housing and shopping projects could be constructed to encourage trips on foot or bike or by transit, allowing residents the option of not driving. For example, transit-oriented development concentrates homes and shops near transit hubs to facilitate the use of transit.

There are many good policies to promote smart growth, and many good reasons to support them. Global warming concerns should be central among those reasons.

Assumptions and Methodology

Projections of future global warming pollution from automobiles depend a great deal on the assumptions used. This section details the assumptions we made about future trends and explains the methodology we used to estimate the impact of various programs.

Baseline Light-Duty Vehicle Carbon Dioxide Emissions

Carbon dioxide emissions from light-duty vehicles (cars and light trucks) in Maryland in 1990 and 2000-2004 were based on state-specific motor gasoline usage data from U.S. Department of Energy, Energy Information Administration (EIA), *State Energy Data*.[91] Fuel consumption data for the transportation sector in BTU was converted to carbon dioxide emissions based on conversion factors from EIA, *Annual Energy Outlook 2003*, Appendix H and EIA, *Emissions of Greenhouse Gases in the United States 2001*, Appendix B. The proportion of transportation-sector gasoline emissions attributable to light-duty vehicles was estimated by dividing energy use by light-duty vehicles by total transportation-sector motor gasoline use as reported in EIA, *Annual Energy Outlook 2006*.

Vehicle-Miles Traveled

Historic vehicle-miles traveled data for Maryland were obtained from the Maryland State Highway Administration, *Travel-Millions of Annual Vehicle Miles*, downloaded from www.sha.state.md.us/shaservices/trafficreports/vehicle_miles_of_travel.pdf, 30 August 2006. Projected VMT was calculated on the assumption that 1995-2005 growth rates will continue in the future.

VMT Percentages by Vehicle Type

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.

To calculate Maryland-specific data on VMT splits, we obtained annual registration data from *Highway Statistics*, Tables MV-1 and MV-9 for 1996 through 2003, and from Table MV-201 for 1990 through 1995. Because data from 1995 and earlier do not include separate figures for light-duty trucks, we estimated light-duty trucks as a percentage of all registered trucks using the 1996 ratio reported in MV-9. We then multiplied the number of registered vehicles by the average miles driven per vehicle type, as reported in FHWA Table VM-1. From this, we obtained a VMT split between cars and light-duty trucks.

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. Recent rises in fuel prices have prompted more consumers to purchase cars instead of trucks than has been the case for several years, but it is too early to predict how long or significant this trend might be. Thus, for this analysis, we incorporate EPA's long-term projection that light trucks will represent an increasing portion of light-duty vehicle sales.

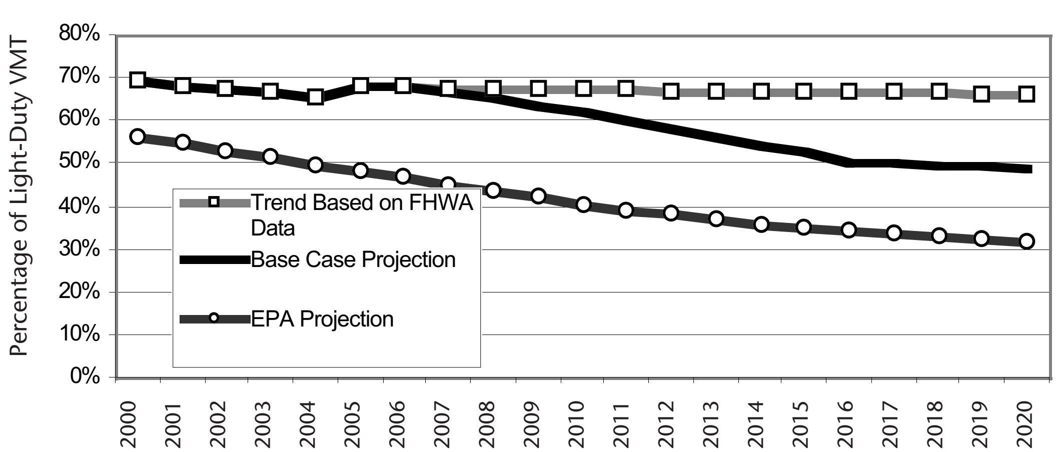
In order to estimate a trend that reflects both the more car-heavy current makeup of VMT and the long-term trend toward increasing travel in light trucks, we created two curves, one extrapolating the continued linear decline in the car portion of light-duty VMT based on trends in FHWA data from 1990 to 2004 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. (See Figure 10.)

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*, September 2001.

VMT Percentages by Vehicle Age

Vehicle-miles traveled by age of vehicle were determined based on VMT accumulation data presented in EPA, *Fleet*

Figure 10. Percentage of Light-Duty Vehicle-Miles Traveled in Cars



Characterization Data for MOBILE6: Development and Use of Age Distributions, Average Annual Mileage Accumulation Rates, and Projected Vehicle Counts for Use in MOBILE6, September 2001.

Vehicle Carbon Dioxide Emissions

Per-mile carbon dioxide emissions from vehicles were based on assumed levels of carbon dioxide emissions per gallon of gasoline (or equivalent amount of other fuel), coupled with assumptions as to miles-per-gallon fuel efficiency.

For conventional vehicles, a gallon of gasoline was assumed to produce 8,869 grams (19.6 pounds) of carbon dioxide. This figure is based on carbon coefficients and heat content data from EIA, *Emissions of Greenhouse Gases in the United States 2001*, Appendix B. Fuel economy estimates were based on EPA laboratory fuel economy values from EPA, *Light-Duty Automotive Technology and Fuel Economy Trends: 1975 Through 2004*, April 2004, multiplied by a degradation factor obtained from EIA, *Assumptions to the AEO 2006*. (The degradation factor represents the degree to which real-world fuel economy falls below that reported as a result of EPA testing.)

For hybrid-electric vehicles used to comply with AT-PZEV requirements, fuel economy was estimated to exceed that of conventional vehicles by 30 percent, per National Research Council, National Academy of Engineering, *The Hydrogen Economy: Opportunities, Costs, Barriers and R&D Needs*, the National Academies Press, 2004. This same document provided the assumption that hydrogen fuel-cell vehicles would achieve 58 percent greater fuel economy than conventional vehicles. This figure was then input into the Argonne National Laboratory's Greenhouse Gases Regulated Emissions and Energy Use in Transportation (GREET) model version 1.5a to produce an estimated grams CO_2/gasoline gallon equivalent for fuel-cell vehicles of 3,816 grams, which was then used to estimate emissions from hydrogen fuel-cell vehicles manufactured to comply with the LEV II program. (Fuel-cycle emissions from hydrogen fuel-cell vehicles were used in lieu of direct tailpipe emissions since fuel-cell vehicles emit no pollution from the tailpipe and it was assumed that the hydrogen fuel—and its associated emissions—would be created within Maryland. Estimated emissions from electricity used to generate hydrogen w
re not adjusted for Maryland's power mix.)

For the global warming emission standards, we assumed percentage reductions in per-mile vehicle emissions as described in 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.

Emissions from vehicles complying with the standards were estimated by multiplying the percentage reduction in emissions attributed to the standards for each model year by the 2004 emissions level for that class of vehicles. For all years until 2016, vehicle 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. 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).

Advanced Technology Program Implementation

In calculating emission reductions resulting from LEV II's advanced technology program, we assumed implementation of the program beginning in model year 2011 with the same requirements as the California program. Vehicles meeting the AT-PZEV standards were assumed to be "Type D" Hybrids (similar to the Toyota Prius), while vehicles meeting pure ZEV standards were assumed to be hydrogen fuel-cell vehicles whose fuel was produced from natural gas.

Percentages of vehicles meeting PZEV, AT-PZEV and pure ZEV criteria were estimated in the following manner:

- Light-duty vehicle sales in Maryland for each category (cars and light trucks) were estimated based on year 2004 new vehicle registration figures from Alliance of Automobile Manufacturers, *Light Truck Country*, downloaded from autoalliance.org/download/lighttruck.pdf, 27 October 2005, with the light truck category divided into heavy and light light-duty trucks using EPA fleet composition estimates as described above. These figures were then multiplied by the percentage of sales subject to the advanced technology program for each year.
- This number was multiplied by 0.9 to account for the six-year time lag in calculating the sales base subject to the advanced technology program. (For example, a manufacturer's requirements in the 2009 through 2011 model years are based on percentages of sales during model years 2003 through 2005.)
- Where necessary, these values were multiplied by the percentage of vehicles supplied by major manufacturers versus all manufacturers as calculated from Ward's Communications, *2003 Ward's Automotive Yearbook*, 233. (Non-major manufacturers may comply with the entire advanced technology program requirement by supplying PZEVs.)
- This value was then multiplied by the percentage sales requirement to arrive at the number of advanced technology program credits that would need to be accumulated in each model year.
- The credit requirement was divided by the number of credits received by each vehicle supplied as described in California Environmental Protection Agency, Air Resources Board, *Final Regulation Order: The 2003 Amendments to the California Zero Emission Vehicle Regulation*, 9 January 2004.
- The resulting number of vehicles was then divided by total light-duty vehicle sales to arrive at the percentage of sales required of each vehicle type.
- No pure ZEVs were assumed to be required for sale in Maryland until the 2012 model year. For the 2012 through 2017 model years, in which the pure ZEV requirement is based on a specific number of California sales, we divided the annual pure ZEV requirement in the California regulations by the number of new vehicles registered in California in 2001 per Ward's Communications, *2002 Ward's Automotive Yearbook*, 272. We assumed that the same percentage would apply to vehicle sales in Maryland.

It was assumed that manufacturers

would comply with ZEV and AT-PZEV requirements through the sale of fuel-cell and hybrid passenger cars. While heavier light trucks are also covered by the advanced technology program, manufacturers have the flexibility to use credits accumulated from the sale of cars to achieve the light-truck requirement. Percentages of various vehicle types assumed to be required under the advanced technology program are depicted in Figure 8, page 24 (assuming a roughly 60/40 percentage split between light-truck sales and car sales throughout the entire period).

Fleet Emissions Projections

Based on the above data, two scenarios were created: a "Base Case" scenario based on projected trends in vehicle fuel economy, VMT and vehicle mix and a "Global Warming Pollution Standards" scenario based on the percentage emission reductions proposed by the CARB staff in August 2004. Each scenario began with data from 2004 and continued through 2020.

Projected emissions were based on the year-to-year increase (or decrease) in emissions derived from the estimation techniques described above. These year-to-year changes were then applied to the 2004 baseline emission level to create projections through 2020.

Other Assumptions

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.[92] 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.[93]
- **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.

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