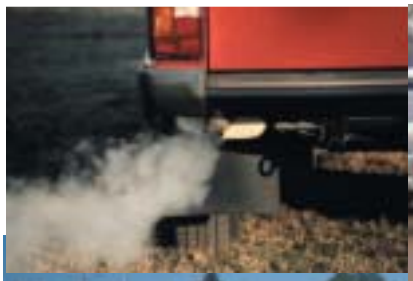

Cars and Global Warming

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

ConnPIRG Education Fund

Spring 2005

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EXECUTIVE SUMMARY

Connecticut could significantly limit its contribution to global warming over the next two decades by implementing a policy to reduce carbon dioxide emissions from cars and light trucks.

Global warming poses a serious threat to Connecticut's future. Scientists project that average temperatures in Connecticut could increase by 2° to 8° F over the next century if no action is taken to reduce emissions of global warming pollution—potentially leading to coastal flooding, increased air pollution and heat-related deaths, and a host of other impacts on Connecticut's environment, public health and economy.

Controlling global warming pollution from the transportation sector—and particularly cars and light trucks—is an essential part of meeting the goals adopted by the Connecticut Legislature and the Conference of New England Governors and Eastern Canadian Premiers.

The transportation sector is responsible for more than one-third of Connecticut's releases of carbon dioxide, the leading global warming gas. Cars and light trucks—such as pickups, minivans and SUVs—are the most important sources of global warming pollution in the transportation sector, responsible for about two-thirds of all transportation sector emissions and about one-quarter of Connecticut's total emissions of global warming pollution.

Carbon dioxide pollution from cars and light trucks in Connecticut is likely to increase by approximately 20 percent over 1990 levels by 2020 unless action is taken to reduce emissions.

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

Connecticut has already taken an important step to reducing greenhouse gas pollution from cars and trucks by adopting the California Clean Cars program.

- The state's implementation of the first stage of the program, known as the Low Emission Vehicle II and Zero Emission Vehicle (LEV II/ZEV) program, will pave the way for the widespread introduction of clean vehicles (such as hybrid-electric and fuel-cell vehicles) that could result in dramatic, long-term reductions in carbon emissions. In the process, it will lead to light-duty carbon dioxide emission reductions of about 1.2 percent below projected levels by 2020.

Connecticut can achieve more significant reductions in its carbon dioxide emissions by implementing the vehicle global warming pollution standards in the Clean Cars program at the earliest allowable date.

- California's standards on global warming pollution from automobiles (also known as the "Pavley" standards for their original legislative sponsor) could produce significant reductions in vehicle global warming emissions as cars are equipped with direct-injection engines, advanced transmissions, improved air conditioning systems, and other advanced technologies. By implementing the program to take effect in model year 2009, Connecticut

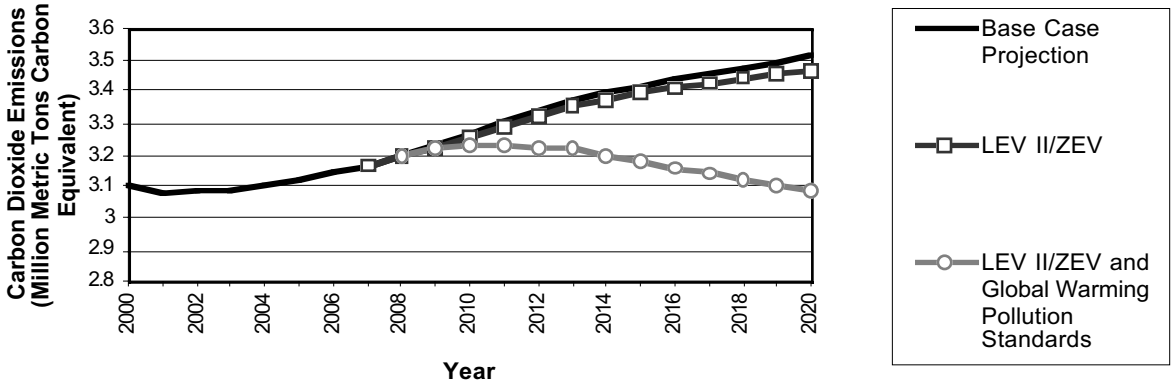
may reduce carbon dioxide pollution from cars and light trucks by about 13 percent below projected levels by 2020.

- Once the program is fully implemented in 2016, consumers are projected to save $3 to $7 every month as a result of the standards.
- Even with implementation of both components of the Clean Cars program, carbon dioxide pollution from cars and light trucks in 2020 would be only slightly lower than pollution in 2000 because of a large projected increase in vehicle travel. Thus, Connecticut will likely need to adopt additional policies to reduce emissions from the transportation sector if it wishes to achieve the regional goal of reducing overall global warming pollution to 10 percent below 1990 levels by 2020.

Connecticut should move quickly to adopt policies that will stabilize, and ultimately reduce, emissions of carbon dioxide from cars and light trucks.

- In 2005, Connecticut should commit to implementing the vehicle global warming pollution standards in the Clean Cars program so that they take effect in model year 2009.
- Connecticut should adopt other programs—such as clean car incentives that encourage individuals and fleets to purchase vehicles with lower global warming emissions, "smart growth" policies that reduce vehicle travel, transit improvements and other measures—that reduce global warming pollution from the transportation sector.

Figure ES-1. Estimated Connecticut Carbon Dioxide Emissions from Cars and Light Trucks, 2000-2020, Under Policy Scenarios



INTRODUCTION

In 2001, Connecticut, in concert with other New England states and eastern Canadian provinces, took a bold step toward dealing with the problem of global warming by adopting a regional Climate Change Action Plan. The plan, the goals of which have been incorporated into Connecticut state law, committed the region to significant reductions in emissions of global warming pollution over the next two decades and even greater reductions in the future.

As the first step to meeting its commitment, then-Governor Rowland convened the Governor's Steering Committee, whose members are the leaders of key state agencies. The Steering Committee initiated the Climate Change Stakeholder Dialogue (CCSD). Representatives of business, government, academia, and the nonprofit sector gathered to develop a policy roadmap for Connecticut to achieve its global warming pollution reduction goals.

In December 2003, the Climate Change Stakeholder Dialogue issued its recommendations, a package of 55 policies that would begin to stabilize and reduce Connecticut's global warming pollution in the decades to come. The recommendations cover every aspect of energy use in Connecticut, including transportation.

Addressing emissions from the transportation sector is Connecticut's biggest challenge to meeting its emission reduction goals, not only because transportation is the largest source of the state's global warming pollution but also because emissions from the transportation sector are expected to become a larger share of total pollution in coming years.

The technology exists to reduce emissions from cars and light trucks, the largest source of transportation emissions. The tools to make less-polluting cars and trucks already exist, and can be implemented at little cost—and even a net economic benefit—to most consumers. Meanwhile, a host of newer technologies such as plug-in hybrids and fuel cell vehicles could play an important role in meeting the region's long-term pollution reduction goals.

Two key transportation policies recommended by the stakeholders and included in the Climate Change Action Plan submitted to the Legislature were adoption of the LEV II/ZEV program (which sets sales requirements for hybrid-electric and other clean vehicles) and California's emission standards for greenhouse gases.

Connecticut has adopted the Clean Cars program, which originated in California and has been adopted by other states including New York, New Jersey, Massachusetts, and Rhode Island. The first provision of the program, the Low-Emission Vehicle II and Zero-Emission Vehicle standards, requires that a percentage of vehicles sold in Connecticut in coming years be advanced-technology vehicles such as hybrids, which have lower global warming emissions.

Now it is time for Connecticut to implement the Clean Cars program's limits on vehicle global warming pollution. Automakers will reduce emissions of global warming pollutants by incorporating direct-injection engines, continuously variable transmissions, improved air conditioners, and other advanced technologies into new vehicles. California's standards for vehicle global warming pollution will lead to even greater progress toward realizing the promise of new technologies to reduce the impact of our transportation system on the climate.

This report documents the benefits Connecticut may receive from its recent adoption of California's Clean Cars pro-

gram by estimating the impact that both LEV II/ZEV and vehicle global warming pollution standards could have for reducing global warming pollution from motor vehicles in Connecticut. But it also documents the challenge the state faces in reining in emissions from the transportation sector. Even with full implementation of the Clean Cars program, Connecticut will still need to take additional steps to curtail global warming pollution from transportation and achieve its overall climate protection goals.

GLOBAL WARMING AND CONNECTICUT

Human activities over the last century—particularly the burning of fossil fuels—have changed the composition of the atmosphere in ways that threaten dramatic alteration of the global climate in the years to come. Those changes will have serious repercussions for Connecticut.

Causes of Global Warming

Global warming is caused by a blanket of greenhouse gas pollution that traps solar radiation near the earth's surface. This pollution comes largely from cars, power plants, factories and homes when we burn fossil fuels such as coal, oil and gas, as well as from other human and natural processes.

Since 1750, the atmospheric concentration of carbon dioxide has increased by 31 percent. The current rate of increase in carbon dioxide concentrations is unprecedented in the last 20,000 years and the total concentration of carbon dioxide is at its highest point in 420,000 years.[1] Concentrations of other global warming gases, such as methane and nitrous oxide, have increased as well.

As a result, average global temperatures increased during the 20th century by about 1° F. And, if current trends in global warming pollution continue, temperatures could rise by an additional 2.5° F to 10.4° F over the period 1990 to 2100.[2]

Potential Impacts of Global Warming

The impact of this increase in global temperatures will vary from place to place. Because the earth's climate system is extraordinarily complex, warming may be more or less extreme at various points on the globe and at different times during the year. Some regions will experience drier weather, others will receive more precipitation. Storm cycles will also likely be affected in unpredictable yet significant ways.

There is little doubt, however, that the first signs of global warming are beginning to appear, both in Connecticut and around the world. There is also little doubt that global warming could lead to dramatic disruptions in our economy, environment and way of life.

Over the last century, for example, the average temperature in Storrs has increased by 2° F.[3] Meanwhile, precipitation has increased by 20 percent in parts of Connecticut.[4]

Should current emission trends continue, some studies predict that temperatures in Connecticut could increase by 2° F to 8° F by 2100.[5] Others estimate that a 1.8° F increase in average temperature could occur New England-wide as soon as 2030, with a 6° F to 10° F increase over current average temperatures by 2100.[6]

Precipitation levels also could change. Scientific models suggest precipitation may increase by 10 to 20 percent, particularly in winter.[7]

In any event, the impacts of such a shift in average temperature and precipitation would be severe. Among the potential impacts:

- Longer and more severe smog seasons as higher summer temperatures facilitate the formation of ground-level ozone, resulting in additional threats to respiratory health such as aggravated cases of asthma.[8]
- Increased coastal flooding due to higher sea levels, with sea levels projected to rise as much as 22 inches along the Connecticut coast.

- Increased spread of mosquito and tick-borne illnesses, such as West Nile virus and Lyme disease.
- Increased risk of heat-related illnesses and deaths—perhaps a 20 percent increase in heat-related deaths.
- Increased spread of exotic pests and shifts in forest species—including the loss of hardwood forests responsible for vibrant fall foliage displays.
- Shifts in populations of fish, lobster and other aquatic species due to changing water temperatures and changes in the composition of coastal estuaries and wetlands.
- Increases in toxic algae blooms and "red tides," resulting in fish kills and contamination of shellfish.

The likelihood and severity of these potential impacts is difficult to predict. But this much is certain: rapid changes in climate such as those predicted by the latest scientific research would have a dramatic, disruptive effect on Connecticut's environment, economy and public health—unless immediate action is taken to limit our emissions of global warming pollutants such as carbon dioxide.

Global Warming Pollution in Connecticut

Based on an inventory compiled by Northeast States for Coordinated Air Use Management (NESCAUM), emissions of global warming pollution in Connecticut increased by approximately 10 percent between 1990 and 2000.[9] Of those emissions, more than 90 percent were in the form of carbon dioxide released as a result of the combustion of fossil fuels.[10]

The transportation sector is responsible for approximately one-third of Connecticut's contribution to global warming and over one-third of its releases of carbon dioxide.[14] (See Figure 1, page 10.) 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 over two-thirds of all transportation-sector emissions and about one-quarter of Connecticut's total emissions of global warming pollution.[15]

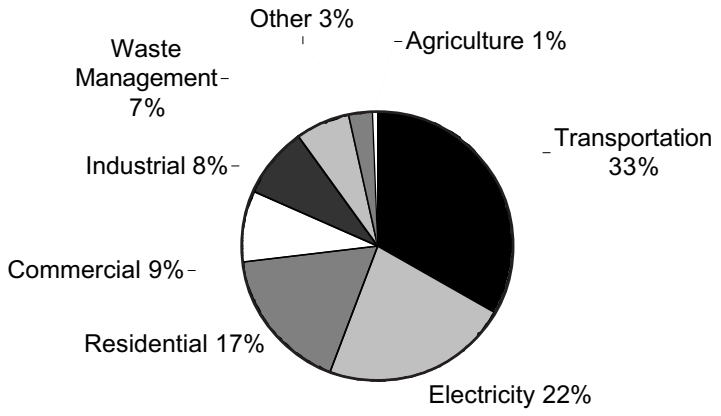
The Regional Climate Change Action Plan and Connecticut's Climate Change Reduction Efforts

Recognizing the threat global warming poses to Connecticut—as well as the opportunity for the state to make a significant contribution to reducing global warming pollution—in 2001, then-Governor Rowland joined with other New England governors and premiers of the eastern Canadian provinces in adopting a regional Climate Change Action Plan.

The plan, since incorporated into Connecticut state law, set goals for the region to stabilize, and ultimately reduce, its emissions of global warming pollutants to the atmosphere. In the short term, the plan calls for regional global warming pollution to be reduced to 1990 levels by 2010. In the medium term, the region is committed to reductions of 10 percent below 1990 levels by 2020. And in the long term, the agreement calls for a reduction in global warming pollution sufficient "to eliminate any dangerous threat to the climate"—a level of reduction estimated by scientists at 75 to 85 percent below present-day levels.[17]

The plan also acknowledged the importance of the transportation sector to

Figure 1. Connecticut Sources of Global Warming Pollution in 2000[16]



any effort to reduce overall global warming pollution, and committed the region to attempt to "slow the growth rate of transportation emissions in the near future."[18] Specifically, the plan recommended that the region "[p]romote the shift to higher efficiency vehicles, lower carbon fuels, and advanced technologies through the use of incentives and education," among other efforts.[19]

A notable shortcoming in the regional plan is the failure to commit to specific, numerical goals for the reduction of global warming pollution from the transportation sector—even though similar goals were set for reductions from the electricity sector and the public sector, and for improvements in energy conservation. The reticence of the governors and premiers to make a concrete commitment on this issue represents a weak link in the agreement—one that could jeopardize the region's ability to meet its overall global warming emission reduction goals.

Another weakness of the plan is its lack of a timeline for achieving the long-term pollution reduction goal of eliminating any threat to the climate. The Connecticut Legislature, however, addressed this particular problem when it formally adopted the goals of the plan. When the Legislature wrote the plan's goals into Connecticut law, it called upon the region's governors and premiers to agree upon a date for achieving the long-term reductions. If there is no regional agreement on the deadline, Connecticut will establish a goal of 2050.[20]

In the past several years, Connecticut has reinforced its commitment to achieving the regional goals by developing a more comprehensive plan of action. The state initiated a public process to develop a list of recommended actions Connecticut could take to reduce its global warming pollution. The extensive stakeholder process involved representatives from business, government, academia and the nonprofit sector. The stakeholders endorsed a list of 55 programs and policies to reduce the state's contribution to global warming from all sectors of the economy, including transportation; land use; residential, commercial, and industrial energy use; agriculture, forestry, and waste management; and electricity generation.

In the spring of 2004, then-Governor Rowland endorsed 38 of the recommendations for implementation or planned implementation by the end of 2005. In addition, the Governor's Steering Committee has submitted a Climate Action Plan to the Legislature that includes all 55 of the stakeholders' policies. According to the stakeholders' analysis, the adoption of all the policies endorsed by the stakeholders will allow Connecticut to meet its global warming pollution reduction goals.[21]

Connecticut has already taken several steps to begin reducing its emissions. The state just adopted California's Clean Cars standards to reduce emissions of toxic and global warming pollution from vehicles (the benefits of this program will be discussed in the following section on "Tools to Reduce Global Warming Pol-

Other Global Warming Pollutants

This report focuses on transportation-related emissions of carbon dioxide—the leading gas 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.[11]

•**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.[12] 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.[13]

lution from Cars and Light Trucks"). Other policies include the state's revised renewable portfolio standard for electricity generation, which will require 7 percent of the state's electricity to come from new, clean renewable resources by 2010, and systems benefit charges on electricity bills that generate funding for energy efficiency and renewable energy programs, though these funds have been raided in the past by the Legislature to pay for unrelated expenses.

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 make the challenge of reducing global warming pollution in Connecticut even greater.

Increasing Vehicle Miles Traveled

Connecticut residents are traveling more miles in their cars and light trucks than ever before. Between 1983 and 2003, the number of vehicle-miles traveled (VMT) annually on Connecticut highways increased from 20.6 billion miles to 31.4 billion miles—an increase of 52 percent.[22] (See Figure 2.)

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.[24] (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" 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.[25]

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 refused to increase CAFE standards for more than a decade, and 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 average real-world fuel economy of light-duty vehicles sold in 2003 was lower than the average fuel economy of vehicles sold in

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 lower lifecycle carbon emissions.

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.

Figure 2. Connecticut VMT Increased More than 50 Percent between 1983 and 2003[23]

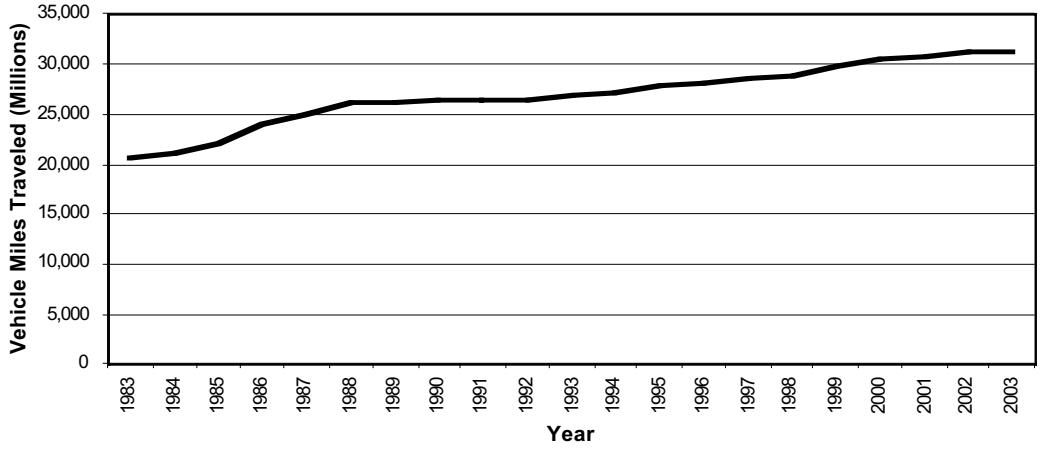
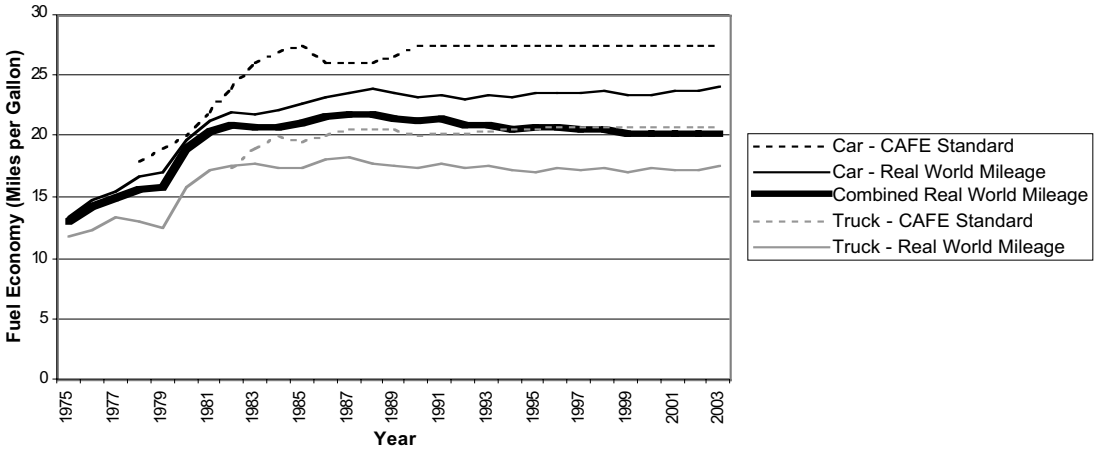


Figure 3. Average Fuel Economy for New Light-Duty Vehicle Fleet on the Decline[27]



1981. Indeed, the average real-world fuel economy of new cars and light trucks actually *declined* by 7 percent between 1988 and 2003.[26] (See Figure 3.)

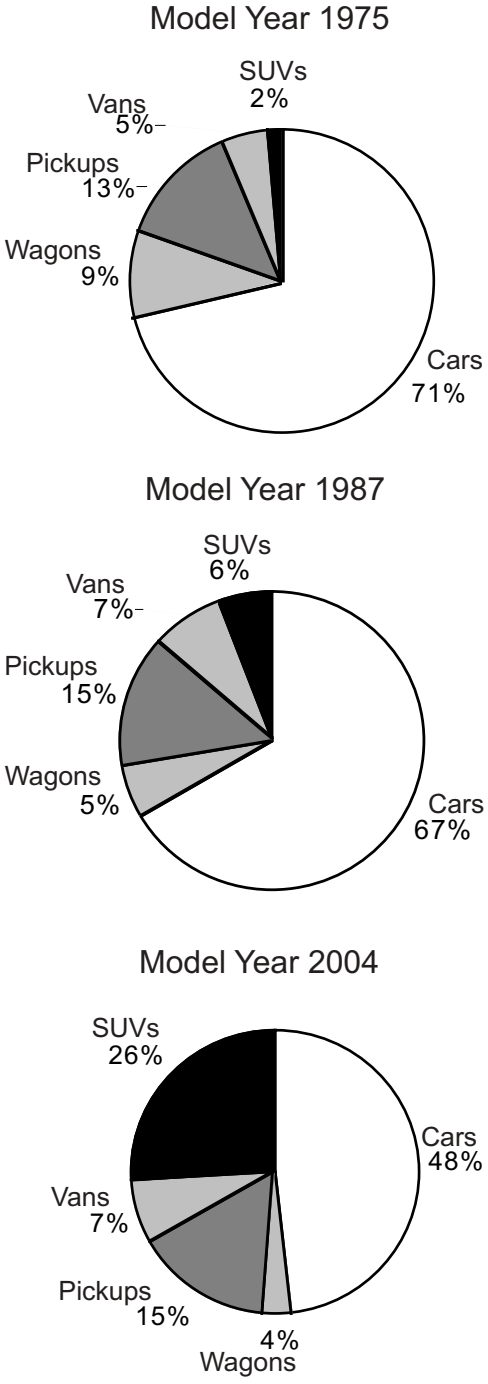
Amid growing public pressure to improve vehicle fuel economy, the U.S. Department of Transportation is increasing CAFE standards for light trucks by a modest 1.5 mpg between 2005 and 2007. While this action does not go far enough to take advantage of many technologies that could cost-effectively improve 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

Figure 4 (a-c). Light-Duty Vehicle Mix Shifts from Cars to Trucks, Vans and SUVs



light-duty vehicle sales, vans 7 percent, and pick-up 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.[28] (See Figure 4a-4c.)

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.[29]

The trend toward SUVs and light trucks is expected to 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.[30]

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 Connecticut policy-makers as they attempt to reduce global warming pollution from the transportation sector.

Vehicle Carbon Dioxide Pollution in Connecticut: Past and Future

Based on Connecticut-specific fuel consumption data compiled by the U.S. Energy Information Administration (EIA), cars and light-duty trucks released approximately 2.9 million metric tons carbon equivalent (MMTCE) of carbon dioxide into the atmosphere in 1990. By 2000, those emissions had increased by about 7 percent, to 3.1 MMTCE—meaning that cars and trucks were responsible for approximately one-quarter of Connecticut's contribution to global warming in 2000.[31]

Any attempt to project Connecticut's future global warming pollution depends greatly on the assumptions used. The

"Assumptions and Methodology" section at the conclusion of this report describes these assumptions in detail. Simply put, the following projections (which are based largely on data and projections by state and federal government agencies and which we will term the "base case") assume 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 Connecticut light-duty vehicle fleet are projected to experience a 5 percent increase over 2000 levels by 2010, followed by a further 8 percent increase between 2010 and 2020. In other words, by 2020, carbon dioxide emissions from cars and light trucks will exceed 1990 levels by 20 percent in the absence of action to reduce emissions. (See Figure 5.)

An increase of such magnitude would severely challenge Connecticut's ability to meet its intermediate global warming pollution reduction goals of 10 percent below 1990 levels by 2020. Should these increases in emissions from cars and light trucks occur, Connecticut would need to achieve dramatic reductions in global warming pollution—much greater than 10 percent below 1990 levels—from other sectors of the state's economy in order to meet the goals of the plan.

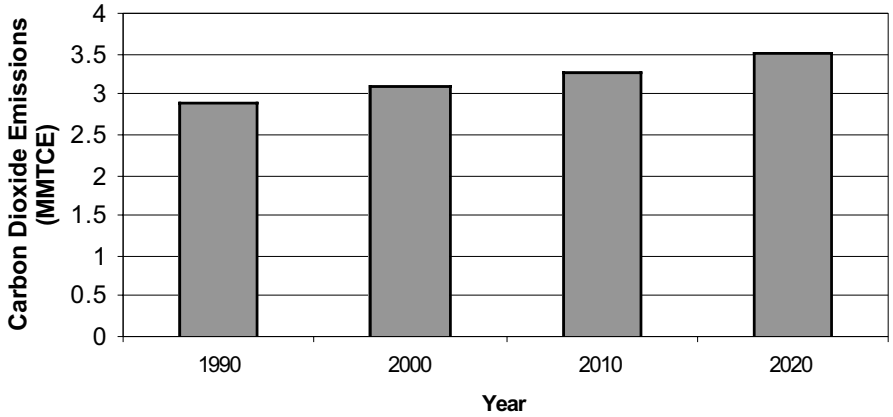
However, this path toward increasing carbon dioxide pollution from cars and light trucks is not inevitable. Public policies that require or encourage the purchase of more fuel-efficient or advanced technology cars can make a significant dent in Connecticut's future emissions of global warming pollution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

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 use units of "carbon equivalent"—the amount of carbon (in the form of carbon dioxide) that would need to be released to create a similar global warming effect. Other documents communicate pollution in terms of "carbon dioxide equivalent." To translate the carbon equivalent to carbon dioxide equivalent, one can simply multiply by 3.66.

Figure 5. Actual and Projected Carbon Dioxide Emissions from Light-Duty Vehicles in Connecticut, 1990-2020



Tools to Reduce Global Warming Pollution from Cars and Light Trucks

Connecticut has many potential tools available to reduce emissions of global warming pollution from the transportation sector. Among the most powerful of those tools are the global warming pollution standards for cars and trucks planned in California.

The Clean Air Act gives most 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 implemented by the state of California, the only state empowered by the Clean Air Act to devise its own emission regulations.

Connecticut—like six other states in the Northeast—has chosen to implement California's Clean Cars standards. The first step of the program targets smog-forming and other pollutants. In addition to reducing emissions of pollution directly dangerous to human health, this phase of the program will lower emissions of global warming gases.

Connecticut and other states now have the opportunity to adopt the Clean Cars program's next phase—standards limiting global warming emissions from cars and light trucks. The standards will bring about significant reductions in carbon dioxide and other greenhouse gas emissions from cars and light trucks over the next decade.

As discussed below, Connecticut's adoption of California's Low-Emission Vehicle II and Zero-Emission Vehicle standards provides a first step in reducing greenhouse gas pollution from vehicles. Adding global warming pollution standards would result in even more significant reductions in emissions of global warming gases from cars and trucks, providing important assistance in Connecticut's efforts to meet the state's climate change goals.

Low-Emission Vehicle II Program

The first stage of the California Clean Cars program—known as the Low Emission Vehicle II and Zero Emission Vehicle, or LEV II/ZEV, standards—seeks to reduce emissions of smog-forming and other hazardous pollutants. It achieves its goals 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. Eventually, the program calls for the sale of zero-emission vehicles (ZEVs). In addition, some of the technological changes encouraged by LEV II/ZEV will reduce emissions of global warming pollutants.

By adopting the program, Connecticut has laid the groundwork to have increasing percentages of advanced-technology vehicles on the road over the next decade and more. The program currently has three main components.

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.

The most recent revision to LEV II/ZEV shifted the emphasis of the program 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 Connecticut until at least model year 2012. Even then, the number of pure ZEVs required for sale in Connecticut would be small, representing less than one percent of new car and light truck sales until model year 2016.[32]

In addition, the California Air Resources Board (CARB), which administers the program, is scheduled to review the status of fuel-cell technology prior to enforcing any pure ZEV requirements for the 2009 model year and beyond.[33]

The current incarnation of LEV II/ZEV, 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. (Note that fuel-cell vehicles have zero emissions provided that the electricity that is used to create the hydrogen is generated from renewable sources.)

Partial Zero-Emission Vehicle (PZEV) Credits

The majority of vehicles that automakers produce to comply with LEV II/ZEV 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 Connecticut 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.

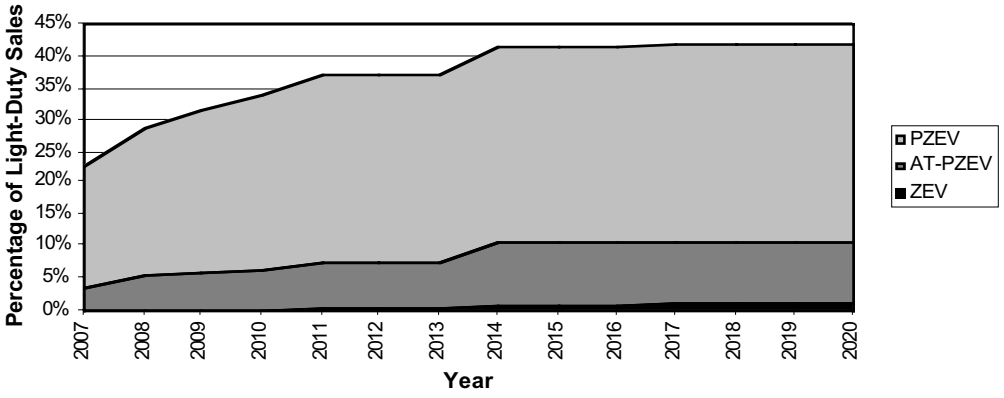
Advanced Technology PZEVs (AT-PZEVs)

The greatest near-term global warming impact of LEV II/ZEV will likely come from provisions to encourage the sale of PZEVs that also 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 up to 40 percent of their LEV II/ZEV sales obligations in the early years of the program through the sale of AT-PZEVs.

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 85,000 hybrids were sold in the U.S. in 2004, almost double sales of the previous year.[34]

Thus far, four models of vehicles have been certified to AT-PZEV emission standards: the Toyota Prius, the Honda Civic hybrid, the Ford Escape hybrid, and the natural gas-powered Honda Civic GX.[35] (Several other hybrid vehicles, such as the Honda Accord, 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 warm-

Figure 6. LEV II/ZEV Percentage of Light-Duty Vehicle Sales, 2007 through 2020



ing 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. By the end of 2005, the demand crunch could ease slightly if automakers introduce six additional hybrid models as planned—including hybrid versions of the Nissan Altima and Toyota Highlander—that could qualify for AT-PZEV credit.[36]

Should automakers choose to maximize their use of AT-PZEVs to comply with LEV II/ZEV—and do so using vehicles similar to the Toyota Prius—hybrids could make up about 3.5 percent of Connecticut car and light truck sales in 2008, increasing to 7 percent by 2012. (See Figure 6.) This translates to sales of about 6,500 hybrids in Connecticut in 2007, increasing to approximately 19,000 annually by 2016. Because LEV II/ZEV 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.

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. LEV II/ZEV does provide additional credit to hybrid-electric vehicles that attain a greater share of their power from an electric motor (generally allowing them to achieve lower carbon dioxide emissions), but these credits are not directly tied to global warming pollution. 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.[38]

LEV II/ZEV 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 LEV II/ZEV 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 Connecticut car and truck fleet.

An example of the potential power of the program to hasten technological change is the development of hybrid vehicles. California's adoption of the original ZEV requirement 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

Additional Uncertainty: Alternative Compliance Paths

In addition to the compliance flexibility that California designed into LEV II/ZEV, Connecticut offers manufacturers two early compliance options that introduce greater uncertainty about how automakers will choose to comply with the program's requirements, especially in the early years of implementation.

Both alternative compliance paths allow manufacturers to earn credit for LEV II/ZEV-compliant vehicles placed in Connecticut or California before the program begins in Connecticut.[37] In one alternative compliance option, automakers can receive credit in Connecticut for credits earned in California by selling advanced-technology vehicles before LEV II/ZEV began there. On January 1, 2008, any credits that a manufacturer has available in California can be counted in Connecticut also, adjusted for Connecticut's smaller vehicle market. The manufacturer can then use those credits to offset requirements of LEV II/ZEV in Connecticut.

Connecticut's other alternative compliance option encourages manufacturers to sell cleaner cars in Connecticut as soon as possible. Each low- or zero-emission car sold in Connecticut before LEV II/ZEV officially begins in model year 2008 will reduce the number of vehicles the manufacturer must sell later. For introducing cleaner vehicles in Connecticut before being required to do so, an automaker earns a slight bonus. For example, an AT-PZEV sold in model year 2005 is credited as if it were 2.25 AT-PZEVs sold in 2009 and a PZEV sold in model year 2005 earns 1.5 credits. If a manufacturer accrues fewer credits through this alternative compliance option than it would have had available under the first option discussed above, Connecticut will proportionally credit the automaker for its California credits to make up the difference.

The alternative compliance paths will reduce the number of advanced technology vehicles that manufacturers must sell in Connecticut versus the conventional compliance paths available through the California version of the program. However, because of the many variables involved (including manufacturers' sales plans in both Connecticut and California) it is difficult to make a reliable estimate of how great those reductions will be. As a result, we do not factor the availability of Connecticut's alternative compliance paths into our analysis, meaning that the real carbon dioxide emission reductions achieved by the program could be lower than estimated here.

Photo: Sandy Ridlington

recent advances in fuel-cell vehicle technology.[39]

Similarly, the current form of LEV II/ZEV 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/ZEV Impacts: Short Term

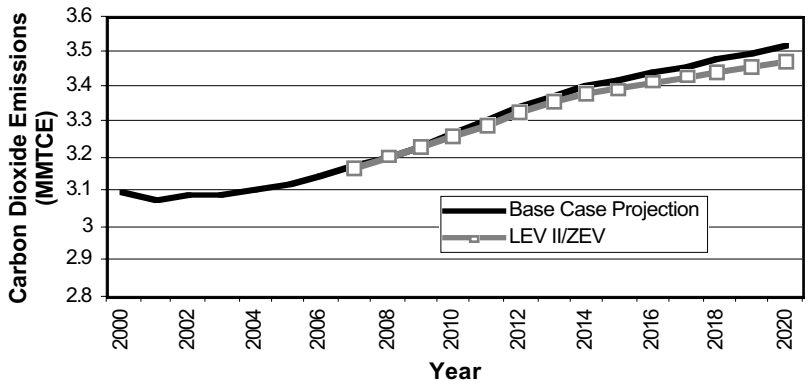
The short-term impact of LEV II/ZEV on carbon dioxide emissions in Connecticut will largely be determined by how automakers choose to comply with the program's flexible provisions. There are almost infinite options available to automakers for compliance—however, it is likely that one or several technologies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

We assume that automakers will take maximum advantage of the ability to meet LEV II/ZEV requirements with PZEVs and AT-PZEVs. We also assume that vehicles sold to meet AT-PZEV requirements are hybrid-electric vehicles with similar technological characteristics 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. We use conservative assumptions about the carbon dioxide emission reductions that could result from hybrid or fuel-cell vehicles. And, as noted above, we do not factor the availability of Connecticut's alternative compliance paths into our analysis.

Using these assumptions, implementation of the program in Connecticut as scheduled beginning in the 2008 model year would reduce light-duty vehicle carbon dioxide emissions by about 1.2 percent versus base case projections by 2020—for a total reduction in emissions of about 0.04 MMTCE. (See Figure 7.)

Connecticut's adoption of the California Clean Cars standards will result in

Figure 7. Projected Reductions in Carbon Dioxide Emissions Under LEV II/ZEV (Light-Duty Vehicles)



reduced global warming and toxic pollution from vehicles as the LEV II/ZEV program takes effect. Implementing California's vehicle global warming pollution standards will provide even greater emission reductions.

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 California legislation requires 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.[40]

In September 2004, CARB adopted rules for implementation of the global warming pollution standards. As required by the initial legislation, CARB has submitted the regulations to the California Legislature for review during 2005. Those proposed rules provided the basis of our analysis here.

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.[41]

The technological changes needed to achieve these 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. CARB projects that 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.[42]

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 pay $20 more per month on the car loan but will save $23 per month in operating expenses, for a total savings of $3 per month. After the loan is paid off, the consumer will save the full $23 per month. Drivers who purchase a light truck or who pay for the vehicle in cash will experience greater savings.[43] (See Table 1.) These savings assume gasoline costs of $1.74 per gallon.[44] Higher prices will increase the savings to consumers. CARB also projects that the net impact of the standards to the state's economy will be positive, suggesting that ***Connecticut could save money while at the same time reducing the state's overall emissions of global warming gases.***[45]

Assuming that the September 2004 version of the global warming pollution

Table 1. Net Savings for Consumer Under Global Warming Pollution Standards in 2016[46]

	Car	Light Truck
Increased Car Cost	$1,064	$1,029
Increased Monthly Loan Payment	$20	$19
Decreased Monthly Operating Cost	$23	$26
Monthly Net Savings	$3	$7

standards is adopted as proposed, when Connecticut implements those standards on schedule beginning with the 2009 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 12 percent by 2020—for a total reduction of 0.43 MMTCE. (See Figure 8.)

The Need for Additional Actions

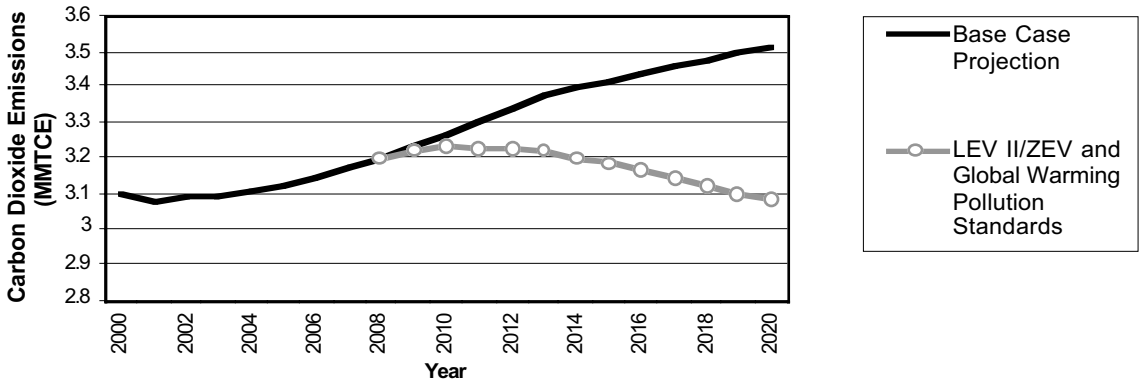
Implementing the Clean Cars program's LEV II/ZEV and global warming pollution standards can contribute significantly to Connecticut's efforts to reduce global warming pollution from the transportation sector. With both components in effect, emissions from light-duty cars and trucks would be 0.6 percent lower 2020 than they were in 2000, compared to 13 percent greater if no action is taken.

Though it yields significant progress and is a major step forward, implementing the Clean Cars program will not be enough to reduce vehicle emissions to 1990 levels by 2010 or to 10 percent below 1990 levels by 2020. Should Connecticut seek to achieve reductions for cars and light trucks similar to those called for in the regional Climate Change Action Plan, the state would need to achieve an additional 0.30 MMTCE of reductions by 2010 and 0.43 MMTCE of reductions by 2020—a level of savings roughly equivalent to that produced by adoption of these programs.

A number of policy options exist for Connecticut to close this gap, including:

- Incentives for individuals and fleets to purchase vehicles with lower carbon emissions. One possible approach is to offer clean car incentives which would give a rebate to car buyers who purchase vehicles that emit less global warming pollution. The rebate could be funded by a fee on purchasers of less efficient vehicles and thus

Figure 8. Reductions in Carbon Dioxide Emissions Under Global Warming Pollution Standards (Light-Duty Vehicles)



could be revenue neutral for the state. The policy is included in the state's Climate Change Action Plan and the Department of Environmental Protection is considering how a program might be implemented.[47] Other New England states are also considering such a program.

- Cents-per-mile insurance, which can be offered by private insurers and allows drivers to purchase vehicle insurance by the mile. Such a program makes drivers more aware of the full costs of each mile driven and can reduce excessive driving. It can also provide a benefit to senior citizens and others who drive less than average. This policy is included on the state's list of actions to be implemented by the end of 2005 or as soon as possible.
- Improved transit service. On the state's list of "immediate" action items is enhancing both bus rapid transit and rail service to reduce the amount citizens need to drive.
- Promote smart growth. The state has committed to reducing the growth in vehicle miles traveled by directing state funding to areas considered appropriate for growth, expanding technical assistance in growth planning, and expanding bicycle and pedestrian infrastructure.

The federal government also could assist Connecticut's efforts to reduce global warming pollution through increasing the federal corporate average fuel economy (CAFE) standard.[48]

POLICY FINDINGS

Attaining the reductions in carbon dioxide emissions required of Connecticut under the regional Climate Change Action Plan will require significant actions to reduce emissions from light-duty vehicles.

To achieve this goal:

- The state should follow through on its commitment to implement the Clean Cars program's global warming pollution standards before December 31, 2005.
- Connecticut should take aggressive action to reduce transportation-sector global warming pollution, including actions that speed the deployment of environmentally preferable vehicles (such as hybrids with low greenhouse gas emissions), reduce the rate of growth in vehicle travel, and encourage improvements in the fuel efficiency of conventional vehicles.

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 Connecticut in 1990 and 2000 were based on state-specific motor gasoline usage data from U.S. Department of Energy, Energy Information Administration (EIA), *State Energy Data 2000 Consumption*, downloaded from www.eia.doe.gov/emeu/states/_use_multistate.html, 7 December 2004. 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 2003*.

Vehicle-Miles Traveled

Historic and projected vehicle-miles traveled data for Connecticut were obtained from Paul Buckley, Transportation Supervising Planner, Connecticut Department of Transportation, 24 November 2004.

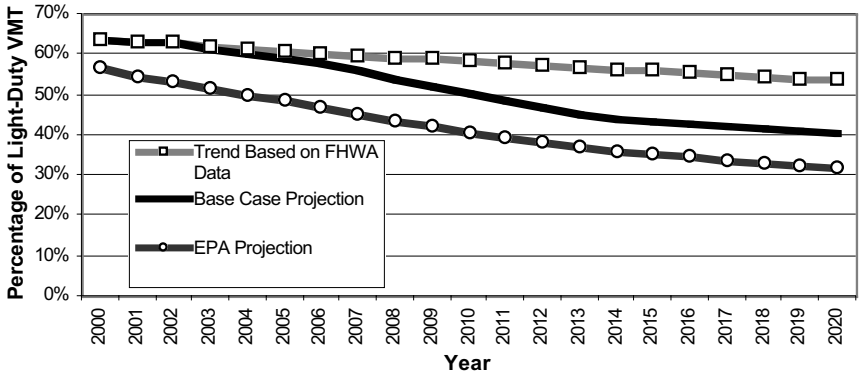
VMT Percentages by Vehicle Type

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. (Connecticut-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 program's benefits slightly lower than will likely occur because per-mile emissions reductions for cars are greater than for trucks and total emission reductions are undercounted in Connecticut 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

Figure 9. Percentage of Light-Duty Vehicle-Miles Traveled in Cars



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 40 percent of light-duty VMT. (See Figure 9.)

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 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 U.S. Department of Energy, Energy Information Administration, *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 of 0.84 for years 2000 through 2020, based on the ratio of revised mpg to lab tested mpg as reported by EPA, *Light-Duty Automotive Technology and Fuel Economy Trends: 1975-2004,* April 2004. (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 ZEV 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 Connecticut. Estimated emissions from electricity used to generate hydrogen were not adjusted for Connecticut's power mix.)

For the global warming gas 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.

LEV II/ZEV Program Implementation

In calculating emission reductions resulting from LEV II/ZEV, we assumed implementation of the program beginning in model year 2008 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 ZEV criteria were estimated in the following manner:

- Light-duty vehicle sales in Connecticut for each category (cars and light trucks) were estimated based on year 2003 new vehicle registration figures from Alliance of Automobile Manufacturers, *Light Truck Country*, downloaded from autoalliance.org/archives/000141.html, 27 August 2004, 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 ZEV 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 ZEV 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 ZEV program requirement by supplying PZEVs.)

- This value was then multiplied by the percentage sales requirement to arrive at the number of ZEV 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 Connecticut 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 Connecticut.

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 LEV II/ZEV, 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 LEV II/ZEV are depicted in Figure 6, page 18 (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, three scenarios were created: a "Base Case" scenario based on projected trends in vehicle fuel economy, VMT and vehicle mix; a "LEV II/ZEV" scenario based on the implementation scenario described above; 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 2000 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 2000 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.[49] To account for this effect, carbon dioxide reductions in each of the scenarios were discounted by 20 percent. This estimate is likely quite conservative:

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.[50]

- **Mix shifting** – We assumed that neither of the policies under study would result in changes in the class of vehicles purchased by Connecticut 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.

NOTES

1. Intergovernmental Panel on Climate Change, *IPCC Third Assessment Report—Climate Change 2001: Summary for Policy Makers*, 2001.

2. Ibid.

3. U.S. Environmental Protection Agency, *Global Warming-State Impacts: Connecticut*, Office of Policy, Planning, and Evaluation, September 1997.

4. Ibid.

5. Ibid.

6. New England Regional Assessment Group, U.S. Global Change Research Program, *Preparing for a Changing Climate: The Potential Consequences of Climate Variability and Change. Foundation Report*, September 2001.

7. See note 3.

8. Impacts are from U.S. Environmental Protection Agency, *Global Warming-State Impacts: Connecticut*, Office of Policy, Planning, and Evaluation, September 1997; and New England Regional Assessment Group, U.S. Global Change Research Program, *Preparing for a Changing Climate: The Potential Consequences of Climate Variability and Change. Foundation Report*, September 2001.

9. Jennifer Weeks, Susan Green, and Marika Tatsutani, Northeast States for Coordinated Air Use Management, *Connecticut Greenhouse Gas Inventory, 1990-2000*, August 2003.

10. Governor's Steering Committee on Climate Change, *Connecticut Climate Change Action Plan*, January 2005.

11. California Environmental Protection Agency, Air Resources Board, *Draft Staff Proposal Regarding the Maximum Feasible and Cost-Effective Reduction of Greenhouse Gas Emissions from Motor Vehicles*, 14 June 2004, 8.

12. U.S. Environmental Protection Agency, *Inventory of U.S. Greenhouse Gas Emissions and Sinks, 1990-2002*, 15 April 2004.

13. James Hansen and Larissa Nazarenko, "Soot Climate Forcing Via Snow and Ice Albedos," *Proceedings of the National Academy of Sciences*, 101(2), 2004.

14. See note 9.

15. Based on data compiled for Clean Water Fund and the National Association of State PIRGs, *Connecticut Responds to Global Warming*, Spring 2004.

16. See note 9.

17. Conference of New England Governors and Eastern Canadian Premiers, *Climate Change Action Plan 2001*, August 2001.

18. Ibid.

19. Ibid.

20. Connecticut General Assembly, *Public Act No. 04-252, An Act Concerning Climate Change*, signed into law on 14 June 2004.

21. See note 10.

22. VMT estimates and projections from Paul Buckley, Transportation Supervising Planner, Connecticut Department of Transportation, personal communication, 24 November 2004.

23. Ibid.

24. Stacy C. Davis, Susan W. Deigel, Center for Transportation Analysis, Oak Ridge National Laboratory, *Transportation Energy Data Book: Edition 22*, September 2002, Chapter 7. The federal government has approved an slight increase in light truck CAFE standards to take effect for the 2005 model year.

25. U.S. Environmental Protection Agency, *Light-Duty Automotive Technology and Fuel Economy Trends: 1975 Through 2004*, Appendix C, April 2004. The federal law that established CAFE standards also established the means for testing of vehicles to determine compliance with the standards. It has long been recognized that these testing methods overstate the "real world" fuel economy of vehicles. EPA has begun to include adjusted figures in its reporting of fuel economy trends and, in its 2004 report, included an estimate of real-world vehicle mileage based on increases in the percentage of urban driving. In this report, all discussions of vehicle fuel economy will refer to "real world" efficiency levels rather than "EPA rated" levels.

26. U.S. Environmental Protection Agency, *Light-Duty Automotive Technology and Fuel Economy Trends: 1975 Through 2004*, Appendix C, April 2004.

27. Real world fuel economy: U.S. Environmental Protection Agency, *Light-Duty Automotive Technology and Fuel Economy Trends: 1975 Through 2004*, Appendix C, April 2004. CAFE standards: U.S. Department of Transportation, *Summary of Fuel Economy Performance*, March 2003.

28. See note 26.

29. Ibid.

30. U.S. Environmental Protection Agency, *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; MOBILE6 run conducted by MASSPIRG Education Fund based on national defaults, January 2003.

31. Based on Jennifer Weeks, Susan Green, and Marika Tatsutani, Northeast States for Coordinated Air Use Management, *Connecticut Greenhouse Gas Inventory, 1990-2000*, August 2003.

32. See "Assumptions and Methodology" for method of calculation.

33. State of California, Air Resources Board, *Resolution 03-4*, 24 April 2003.

34. 2004 sales: Toyota, *Toyota Reaches Two Million in Sales For The First Time in 47-Year History* (press release), 4 January 2005; Honda, *American Honda Sets New All-Time Sales Record* (press release), 4 January 2005; and Steve Geimann, *Bloomberg*, "Ford Expands Lineup of Gas-Electric Hybrid Vehicles (Update 3)," 9 January 2005. 2003 sales: John Porretto, "High Fuel Prices Pumping Up Hybrid Sales," *Associated Press,* 9 May 2004.

35. California Air Resources Board, *Clean Vehicle Search* results for hybrid-electric vehicles, downloaded from www.driveclean.ca.gov/en/gv/vsearch/cleansearch_result.asp?vehicletypeid=7, 1 July 2004; Ford Motor Company, *2005 Ford Escape Hybrid Launches*, 6 August 2004.

36. California Air Resources Board, *Upcoming Clean Cars: Hybrids*, downloaded from www.driveclean.ca.gov/en/gv/vsearch/upcoming.asp, 30 June 2004.

37. State of Connecticut, *Section 22a-174-36b, Low Emission Vehicles II Program,* 3 December 2004.

38. Based on estimated fuel-efficiency improvement factor of 1.45 from hybrid-electric vehicles versus conventional vehicles in National Research Council, National Academy of Engineering, *The Hydrogen Economy: Opportunities, Costs, Barriers and R&D Needs*, The National Academies Press, 2004.

39. The reasons behind the lack of market success of the EV-Plus, EV1 and similar electric vehicles are complex, and may have much to do with automakers' failure to properly market their vehicles to the public.

40. California Assembly Bill 1493, adopted 29 July 2002.

41. 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. Earlier analysis by CARB suggested that even deeper cuts in vehicle emissions could be made more quickly. 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. See California Environmental Protection Agency, Air Resources Board, *Draft Staff Proposal Regarding the Maximum Feasible and Cost-Effective Reduction of Greenhouse Gas Emissions from Motor Vehicles*, 14 June 2004.

42. California Environmental Protection Agency, Air Resources Board, *Addendum Presenting and Describing Revisions to: Initial Statement of Reasons for Proposed Rulemaking, Public Hearing to Consider Adoption of Regulations to Control Greenhouse Gas Emissions from Motor Vehicles,* 10 September 2004.

43. Catherine Witherspoon, California Environmental Protection Agency, Air Resources Board, *Regulations to Control Greenhouse Gas Emissions from Motor Vehicles*, presentation to STAPPA/ALAPCO Fall Membership Meeting, 23-27 October 2004.

44. California Environmental Protection Agency, Air Resources Board, *Technical Support Document for Staff Proposal Regarding Reduction of Greenhouse Gas Emissions from Motor Vehicles: Economic Impacts of the Climate Change Regulations*, 6 August 2004.

45. 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; California Environmental Protection Agency, Air Resources Board, *Addendum Presenting and Describing Revisions to: Initial Statement of Reasons for Proposed Rulemaking, Public Hearing to Consider Adoption of Regulations to Control Greenhouse Gas Emissions from Motor Vehicles,* 10 September 2004.

46. See note 42.

47. *Short Term Actions for Implementation to Reduce Greenhouse Gas Emissions in Connecticut—Initial Progress*, Governor's Steering Committee on Climate Change, 15 November 2004.

48. For a fuller list of transportation policy options, see National Association of State PIRGs, Natural Resources Council of Maine, *A Blueprint for Action: Policy Options to Reduce Maine's Contribution to Global Warming*, Summer 2004.

49. Paul Schimek, "Gasoline and Travel Demand Models Using Time Series and Cross-Section Data from the United States," *Transportation Research Record*, No. 1558 (1996), 83; U.S. General Accounting Office, *Energy Policy Act of 1992: Limited Progress in Acquiring Alternative Fuel Vehicles and Reaching Fuel Goals*, February 2000.

50. 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.