CARS AND GLOBAL WARMING

Policy Options to Reduce Greenhouse Gas Emissions from Massachusetts Cars and Light Trucks

Tony Dutzik

MASSPIRG Education Fund

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Executive Summary

Massachusetts could significantly limit its emissions of greenhouse gases over the next two decades by implementing existing policies and adopting new policies to promote the use of advanced-technology cars and light trucks.

Global warming poses a serious threat to Massachusetts' future. Scientists project that average temperatures in Massachusetts could increase by 4° to 10° F over the next century if no action is taken to reduce our emissions of greenhouse gases — potentially leading to coastal flooding, increased deaths from heat-related causes, increased air pollution and infectious disease, and a host of other impacts.

To address the problem, Massachusetts joined with other New England states and Eastern Canadian provinces to adopt a regional Climate Change Action Plan in 2001. The plan calls for the region to stabilize its emissions of greenhouse gases at 1990 levels by 2010, reduce emissions to 10 percent below 1990 levels by 2020, and to pursue the long-term reductions of 75 to 80 percent that scientists believe will be necessary to stop the growth in greenhouse gas concentrations in the atmosphere.

In order to achieve those goals, Massachusetts will have to stabilize—and ultimately reduce—greenhouse gas emissions from the transportation sector, especially emissions from cars and light-duty trucks. Transportation was responsible for about one-third of the state's greenhouse gas emissions in 1990, with light-duty cars and trucks responsible for about 60 to 70 percent of transportation-sector emissions.

Thankfully, however, a number of public policies can spur both short-term and long-term reductions in emissions of carbon dioxide—the leading greenhouse gas—from cars and light trucks. This report estimates the potential impacts of various policies to encourage reduced carbon dioxide emissions from light-duty vehicles. Among the findings:

Carbon dioxide emissions from cars and light trucks in Massachusetts will increase by approximately 27 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 Massachusetts on a course toward dramatically increased emissions of carbon dioxide from transportation over the next two decades.

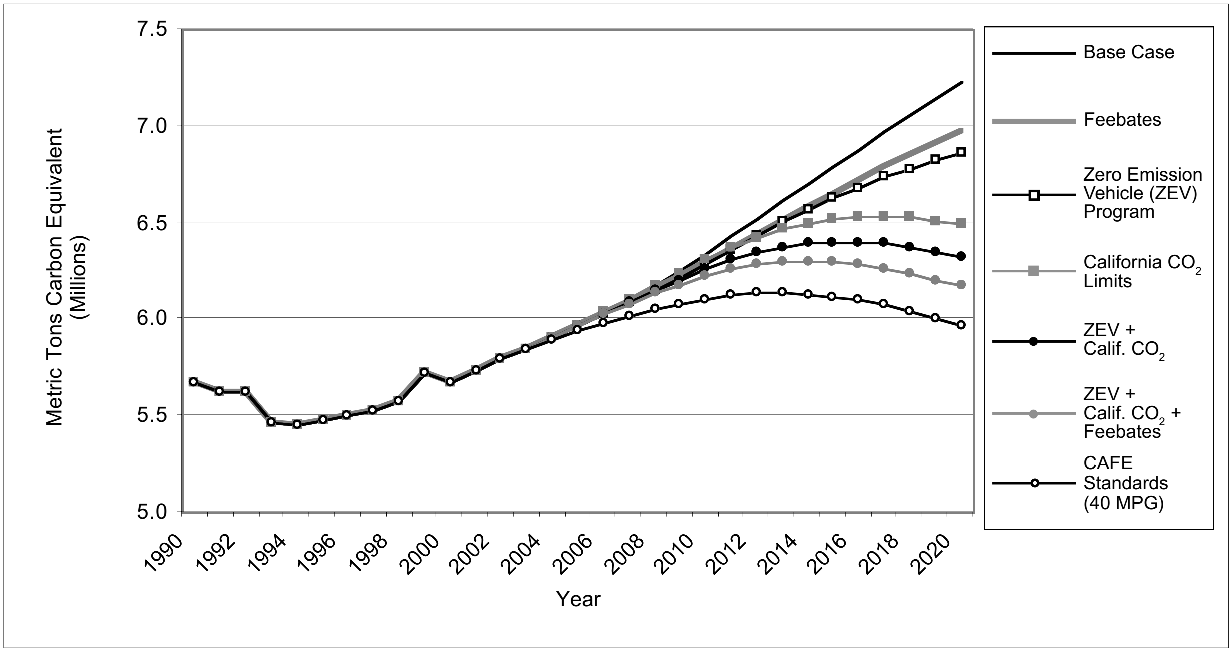
Massachusetts can reduce its carbon dioxide emissions by maintaining its commitment to adopting the nation's toughest pollution standards for automobiles.

- Implementing the Zero-Emission Vehicle (ZEV) program will pave the way for the widespread introduction of clean, advanced technology vehicles—such as hybrid-electric and fuel-cell vehicles—that could result in dramatic, long-term reductions in carbon emissions. In the process, it would lead to light-duty carbon dioxide emission reductions of about 5 percent versus projected levels by 2020.

- Once California has developed regulations for motor vehicle greenhouse gas emissions, Massachusetts should adopt the program, which could reduce carbon dioxide emissions by about 10 percent by 2020.

- Massachusetts law commits the state to adopt the nation's toughest clean air standards for vehicles—including the ZEV program and the California carbon dioxide limits. By combining the two programs, Massachusetts could reduce its carbon dioxide emissions from light-duty vehicles by about 12 percent versus projected levels by 2020.

Estimated Massachusetts Light-Duty Carbon Dioxide Emissions, 1990-2020, Under Policy Scenarios



Other policy changes could lead to even greater reductions in carbon dioxide emissions over the next two decades.

- Adding a revenue-neutral program of "feebates" (fees on the highest polluting vehicles coupled with rebates to owners of cleaner cars) to the two programs listed above could result in total carbon dioxide emission reductions of up to 15 percent versus projected levels by 2020.

- Increasing federal CAFE standards to 40 miles per gallon for cars and light-duty trucks by 2020 could reduce car and light-truck carbon dioxide emissions by about 17 percent below projected levels by 2020, even in the absence of further state action.

- A 50-cent increase in the gasoline tax could lead to reductions of as much as 24 percent in carbon dioxide emissions from cars and light-duty trucks versus projected levels by 2020—although the magnitude of the emission reductions and the effectiveness of such a policy in a small state such as Massachusetts are uncertain.

- Efficiency standards for replacement tires could lead to a 3 percent improvement in fuel economy—with corresponding reductions in carbon dioxide emissions—for all cars and a net financial benefit for many consumers.

- Other policies—such as economic incentives for the purchase of cleaner cars, effective requirements for the purchase of advanced technology vehicles for state fleets, and investments in alternative fuel infrastructure—could lead to additional reductions in carbon dioxide emissions.

- Meeting the goals of the Climate Change Action Plan will also require efforts to limit the expected growth in vehicle travel. Combining the policies above with stabilization or modest reductions in vehicle travel would enable Massachusetts to meet the plan's goal of reducing emissions to 10 percent below 1990 levels by 2020.

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

- The commonwealth should move forward with prompt implementation of the ZEV program and the California carbon dioxide standards following promulgation of the standards in California.
- Massachusetts should devise an effective set of economic incentives—such as a program of feebates—for the purchase of cleaner vehicles and urge federal decision-makers to increase CAFE standards to 40 MPG for cars and light trucks within the next decade.
- Massachusetts should hasten the transition to cleaner, advanced technology vehicles by purchasing these vehicles for state fleets and developing a coordinated plan for the construction of infrastructure for alternative-fuel vehicles.
- The commonwealth should take effective action to limit the projected growth in vehicle-miles traveled over the next two decades. Land-use policies that promote more compact development, investments in transit infrastructure, and expansion of programs to reduce travel demand can all help to achieve this goal.

Introduction

In 2001, Massachusetts—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 committed the region to significant reductions in emissions of greenhouse gases over the next two decades and even greater reductions in the future.

Meeting these goals will require Massachusetts to reduce greenhouse gas emissions from all sectors of the economy—including transportation, which is responsible for more than one-third of the state's greenhouse gas emissions.

A variety of technologies either exist now, or are coming soon, that could help the commonwealth achieve significant reductions in greenhouse gas emissions from cars and light-duty trucks—the largest source of transportation-related emissions. The tools to make dramatically more fuel-efficient and less polluting cars and trucks already exist, and can be implemented at no cost—or even a potential net economic benefit—to most consumers. Meanwhile, a host of newer technologies—ranging from hybrid-electric cars to fuel-cell vehicles that operate on hydrogen—could play an important role in meeting the region's long-term greenhouse gas emission reduction goals.

But these technologies will do no good if they are allowed to languish in auto industry laboratories, emerging only to make brief appearances at car shows. Putting a new generation of cleaner vehicles on the road must be a major public policy priority in the fight against global warming.

A variety of public policies—including regulatory standards, financial incentives and state procurement policies—can help to meet the commonwealth's commitment to reducing its emissions of greenhouse gases. But as this report will show, no single public policy—in and of itself—can achieve this goal. To address climate change, both now and in the future, Massachusetts must adopt a mix of policies that bring about short-term reductions in greenhouse gas emissions from conventional, gasoline-powered vehicles, while hastening the spread of inherently cleaner technologies within the marketplace.

By looking at the potential impacts of various policies on carbon dioxide emissions from the vehicle fleet, this report identifies those options that hold the greatest promise for fulfilling the commonwealth's commitment to take a leadership role in the fight against global warming.

Global Warming and Massachusetts

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 could have serious repercussions for Massachusetts.

CAUSES OF GLOBAL WARMING

Global warming is caused by 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 heat from the sun near the planet's surface. Without a natural greenhouse effect, temperatures on Earth would be too cold for life to survive.

Over the last century, however, the chemical makeup of the Earth's atmosphere has been changing, largely as a result of human burning of fossil fuels, which releases large amounts of carbon dioxide into the atmosphere. 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.[1] Concentrations of other greenhouse gases have increased as well.

The result of these atmospheric changes has been an intensification of the greenhouse effect, in which less of the sun's heat is allowed to escape the Earth's atmosphere. Global average temperatures increased during the 20th century by about 0.6° C (1° F). And, if current trends in greenhouse gas emissions continue, temperatures could rise by an additional 1.4° C to 5.8° C (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 Massachusetts 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, the average temperature in Amherst, Mass. has increased by 2° F and precipitation has increased by 20 percent in some parts of the state.[3] Statewide, average temperatures are estimated to have increased by 1° F between 1885 and 1999.[4]

Should current trends in greenhouse gas emissions continue, some projections suggest that temperatures in Massachusetts could increase by about 4° F in winter and spring and about 5° F in summer and fall 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 to 10° F increase over current average temperatures by 2100. Such an increase in temperature would cause a profound shift in Massachusetts' environment. For example, an increase of 6° F would raise Boston's average annual temperature to that currently experienced by Richmond, Virginia—an increase that would have dramatic impacts on plant and animal life.[6]

Precipitation levels also could change. New England could experience an increase in precipitation of about 10 percent in spring and summer and 20 to 60 percent in winter by 2100.[7] Some projections suggest that the overall higher level of precipitation will be interrupted by periodic, long-term droughts.[8]

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.

- Shifts in forest species due to changing temperatures and increased spread of exotic pests.
- Shifts in oceanic fish populations 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.
- Declines in freshwater quality due to more severe storms, increased precipitation and intermittent drought.
- The reduction of trout and other coldwater fish populations.
- Increased coastal flooding due to higher sea levels and more severe storms.
- Increased spread of mosquito and rodent-borne illnesses, such as Eastern equine encephalitis and Hanta virus, and shifts in occurrence of tick-borne illnesses such as Lyme disease.
- Increased risk of heat-related illnesses and deaths.
- Disruption to traditional New England industries such as fall foliage-related tourism, maple syrup production and skiing.[9]
- Reduced crop yields.[10]
- Increased coastal erosion, saltwater intrusion of aquifers, and the need for increased investment in seawalls and other forms of infrastructure to protect coastal areas.

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

The good news is that Massachusetts—acting on its own—can play a significant role in reducing emissions of greenhouse gases, while showing the way for other states to make their own contributions to the fight against global warming.

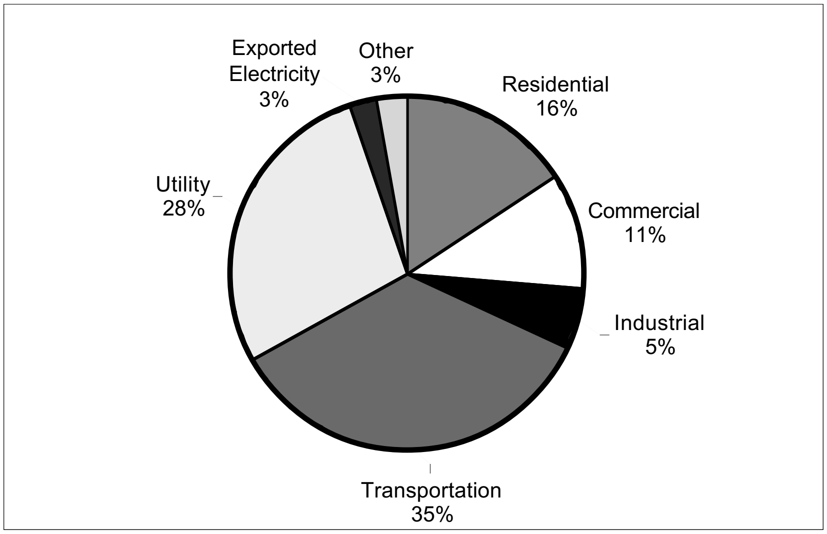
GREENHOUSE GAS EMISSIONS IN MASSACHUSETTS

In 1990 (the last year for which reliable estimates are available) Massachusetts was responsible for net emissions of approximately 73 million metric tons (about 81 million short tons, or 20 million metric tons of carbon equivalent) of carbon dioxide into the atmosphere.[11] Approximately one-third of those emissions—28.6 million metric tons, or 7.8 million metric tons carbon equivalent (MMTCE)—came from the transportation sector.[12]

On the world stage, Massachusetts is a significant contributor to the buildup of greenhouse gases in the atmosphere. According to United Nations figures, Massachusetts' 1990 carbon dioxide emissions would have ranked 39th among the nations of the world that reported their emissions that year, just below Egypt and just above Hungary.[14]

Carbon dioxide emissions from the Massachusetts transportation sector are also significant on the global scale. Emissions ***solely*** from the Massachusetts transportation sector in 1990 would have ranked the state 64th among the world's countries for overall carbon dioxide releases, just above Hong Kong and just below Ireland.[15] In other words, carbon dioxide emissions from transportation in Massachusetts exceed the total carbon dioxide emissions of more than half the world's nations.

Figure 1. Massachusetts Sources of Greenhouse Gas Emissions from Energy Production and Use, 1990[13]



THE REGIONAL CLIMATE CHANGE ACTION PLAN

Recognizing the threat global warming poses to Massachusetts—as well as the opportunity for the commonwealth to make a significant contribution to reducing greenhouse gas emissions—Massachusetts Gov. Jane Swift joined with other New England governors and premiers of eastern Canadian provinces in 2001 in adopting a regional Climate Change Action Plan.

The plan set goals for the region to stabilize, and ultimately reduce, its emissions of greenhouse gases to the atmosphere. In the short term, the plan calls for regional greenhouse gas emissions 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 greenhouse gas emissions sufficient "to eliminate any dangerous threat to the climate"—a level of reduction estimated by scientists at 75 to 80 percent below present-day levels.[16]

The plan also acknowledged the importance of the transportation sector to any effort to reduce overall greenhouse gas emissions, and committed the region to attempt to "slow the growth rate of transportation emissions in the near future."[17] 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.[18]

Notable in the plan's language, however, is the failure to commit to specific, numerical goals for the reduction of greenhouse gas emissions 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 greenhouse gas reduction goals.

Transportation and Carbon Dioxide: A Primer

A gallon of gasoline contains a set amount of carbon, all of which is released to the atmosphere when the gasoline 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 20 pounds of carbon dioxide is released to the atmosphere. Other fuels have greater or smaller percentages of carbon.

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 only three ways to limit carbon dioxide emissions from motor vehicles:

1) Reduce the number of miles traveled.
2) Improve the efficiency of the vehicle so that less fuel is consumed for every mile traveled.
3) Switch to fuels with a lower carbon content.

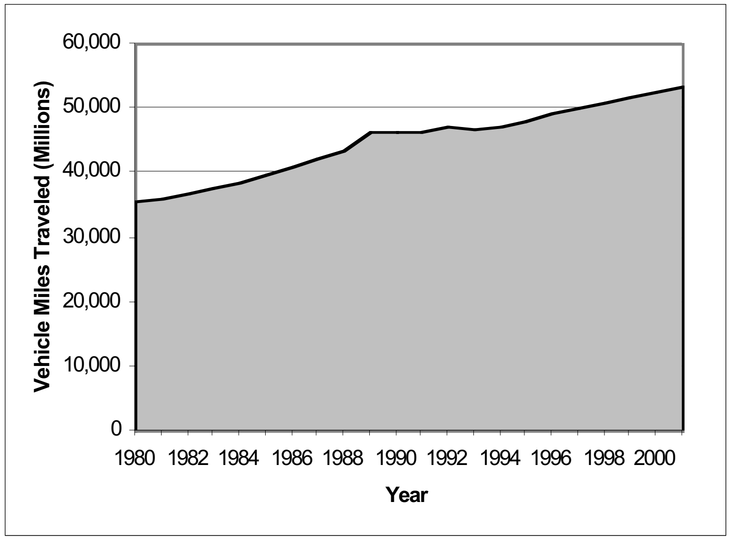
THE TRANSPORTATION CHALLENGE

The challenge of reducing greenhouse gas emissions from cars and trucks is formidable, and growing increasingly so with each passing year. Three recent trends in the transportation sector have made the challenge of reducing greenhouse gas emissions in Massachusetts even greater.

Increasing Vehicle Miles Traveled

Massachusetts residents are traveling more miles in their cars and light trucks than ever before. Between 1980 and 2001, the number of miles traveled annually on Massachusetts highways increased from 35.4 billion miles to 53 billion miles—an increase of 50 percent.[19]

Figure 2. Vehicle Miles Traveled in Massachusetts, 1980-2001[20]



Stagnating Fuel Economy

The imposition of federal Corporate Average Fuel Economy (CAFE) standards in the 1970s led to dramatic improvements in the fuel efficiency of American cars and light duty trucks. The CAFE standards called for a gradual increase in fuel economy standards during the 1970s and 1980s, topping out at an average fuel economy for cars of 27.5 miles per gallon (MPG) by 1990 and 20.7 MPG for light trucks by 1996.[21]

In the decade-and-a-half following enactment of the CAFE standards, the "real world" fuel economy of passenger cars nearly doubled—from 13.5 MPG in 1975 to 24.4 MPG in 1988. Similarly, light trucks experienced an increase in real-world fuel economy from 11.6 MPG in 1975 to 18.4 MPG in 1987.[22]

However, the momentum toward more fuel efficient cars has not only stalled since the late 1980s, it has actually reversed. The federal government has refused to increase CAFE standards in 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 (which did not factor in the shift to more urban driving) found that real-world fuel economy for cars sold in 2001 was lower than it was for cars sold in 1988.[23] Worse, real-world fuel economy for light trucks sold in 2001 was lower than for ***any year*** since 1981.[24] As a result, Americans get scarcely more miles per gallon from their new vehicles than they did during the Reagan administration.

Amid growing public pressure to improve vehicle fuel economy, in December 2002 the U.S. Department of Transportation announced its intention to propose a modest increase in CAFE standards of 1.5 MPG for light trucks between 2005 and 2007. While this proposal fails 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 emissions. The effects of this proposed change are included in the base case analysis that follows.

The Shift to 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 nosedived—thanks to the dramatic shift in purchasing habits toward sport utility vehicles (SUVs), vans and light trucks.

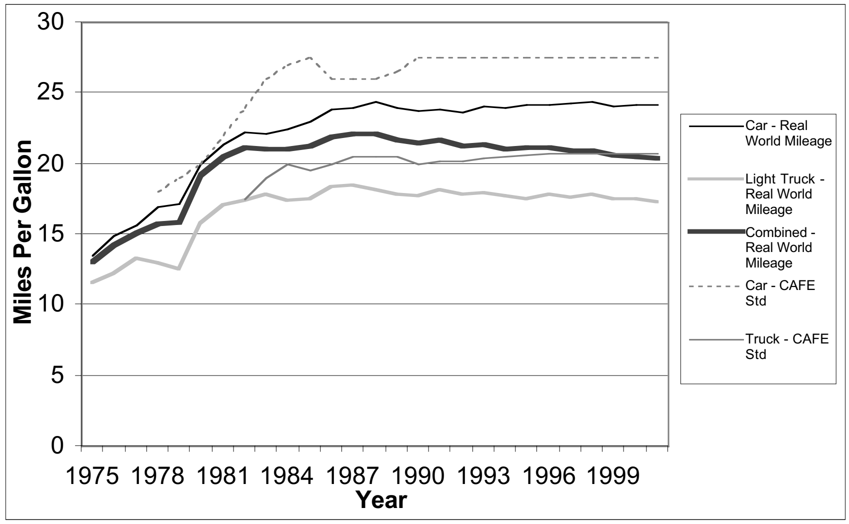
In 1975, when the first federal CAFE standards were enacted, SUVs made up 2 percent of the light-duty vehicle market, vans 4 percent, and pick-up trucks 13 percent. By 2001, however, SUVs accounted for 21 percent of light-duty vehicle sales, vans 9 percent, and pick-up trucks 17 percent. The light-duty market share of passenger cars and station wagons plummeted over the same period from 81 percent to 53 percent.[25]

This shift in purchasing habits has caused the average fuel economy of the entire new light-duty vehicle fleet to dip to 20.4 MPG in 200—lower than at any time since 1980 and down by nearly 8 percent from the historical peak in 1987 and 1988.[26]

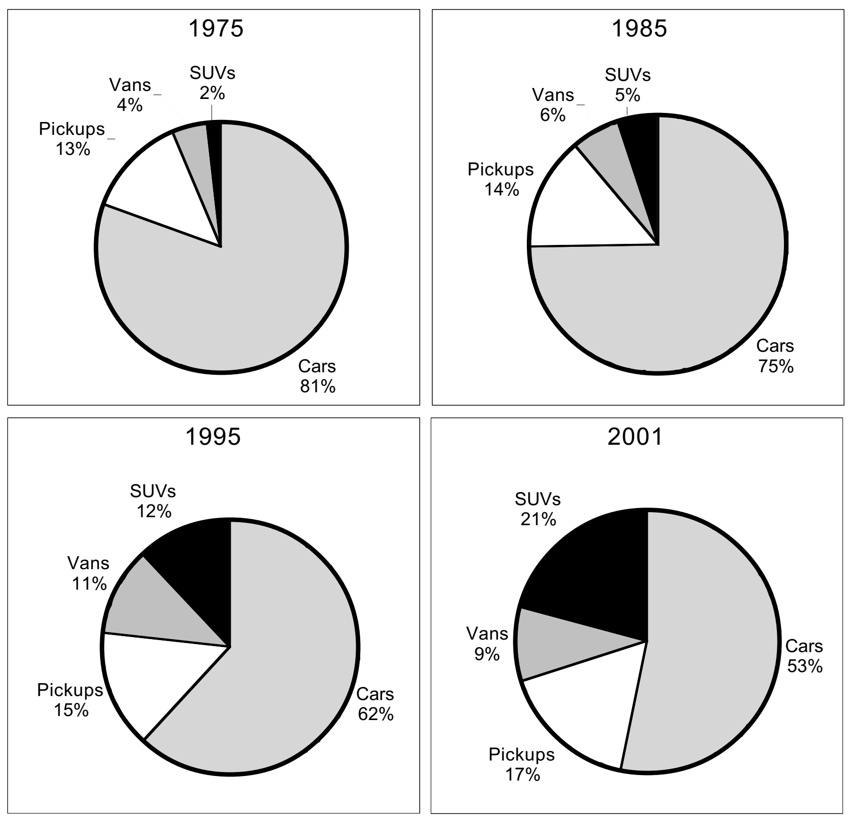
The trend toward SUVs and light trucks is expected to continue, with light trucks making up an increasing percentage of the entire light-duty fleet as time goes on. The Environmental Protection Agency projects that, by 2020, 64 percent of all light-duty vehicles on the road will be light trucks, making up 59 percent of the vehicle-miles traveled (VMT) on America's roads.[27]

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 Massachusetts policy makers as they attempt to reduce greenhouse gas emissions from the transportation sector.

Figure 3. Average Fuel Economy for New Light-Duty Vehicle Fleet, 1975-2001



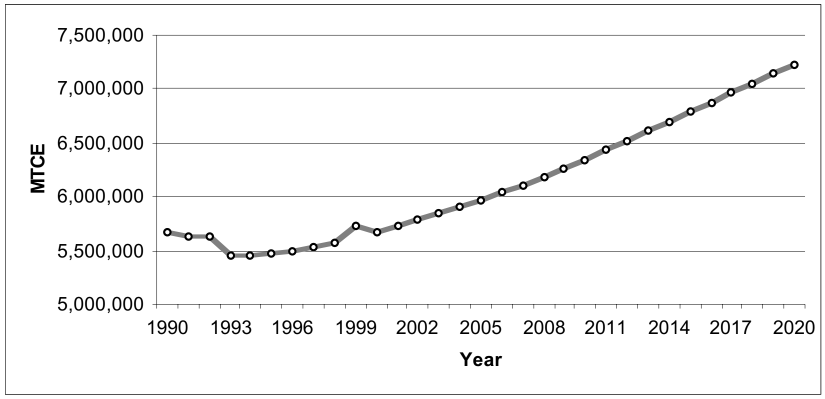
Figures 4 (a-d). Percentage of New Light-Duty Vehicle Sales, U.S.



MASSACHUSETTS EMISSION TRENDS

As noted above, the Massachusetts transportation sector emitted approximately 7.8 MMTCE of carbon dioxide in 1990. The state's 1990 greenhouse gas inventory did not estimate emissions specifically from cars and light-duty trucks, but did attribute 71 percent of the transportation sector's carbon dioxide emissions to motor gasoline (not including diesel fuel).[28] This would translate to 5.5 MMTCE of carbon dioxide emissions from the combustion of motor gasoline, the vast majority of which is consumed by light-duty cars and trucks.

Figure 5. Massachusetts Carbon Dioxide Emissions from Light-duty Vehicles (Base Case)



To estimate carbon dioxide emissions over the 1990-2020 period, this analysis relies on state estimates and projections of total vehicle-miles traveled, national estimates of the proportion of VMT driven in cars versus light trucks, and estimates of per-mile carbon dioxide emissions for various vehicle types supplied by the Argonne National Laboratories' Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation (GREET) model.[29]

Based on these figures, carbon dioxide emissions from the Massachusetts light-duty vehicle fleet were estimated to be approximately 5.7 MMTCE in 1990. To the extent that this estimate is higher than that derived from the 1990 greenhouse gas inventory, it is likely due to differences in the vehicle mix in Massachusetts versus the nation as a whole. For example, in 1992, cars represented 88 percent of the light-duty vehicle fleet in Massachusetts versus 79 percent nationally. These differences persist to the present day, although they are narrowing: in 2001, cars made up 69 percent of the Massachusetts light-duty fleet versus 62 percent nationally.[30]

Because light trucks, on average, produce more carbon dioxide emissions per mile, the use of the EPA's national assumptions for vehicle mix will tend to slightly inflate estimated carbon dioxide emissions in Massachusetts in the early years of the 1990-2020 time period studied. However, because it is difficult to accurately adjust for differences in vehicle mix, and because the differences between the state and national vehicle mixes are tending to narrow over time, the national assumptions are used in the analysis that follows.

Table 1. Massachusetts Carbon Dioxide Emissions from Light-duty Vehicles (Base Case)

Year	Emissions (MMTCE)	Increase Over 1990
1990	5.68	—
1995	5.48	-4%
2000	5.68	0%
2005	5.97	5%
2010	6.34	12%
2015	6.79	20%
2020	7.22	27%

Looking at the trends, carbon dioxide emissions from the light-duty fleet in Massachusetts were estimated to have declined between 1990 and 1997 as older vehicles subject to less stringent fuel-economy standards were phased out of the vehicle fleet. (See Figure 5.) However, the stagnation of CAFE standards—coupled with increasing VMT and the shift to SUVs and light-duty trucks—began to make its presence felt in the late 1990s. By 2000, light-duty emissions of carbon dioxide had returned to 1990 levels. And—if average vehicle fuel economy continues to stagnate and trends toward increased VMT and use of light-duty trucks continue—Massachusetts could see a dramatic escalation of carbon dioxide emissions in the decades ahead.

Without further action to reduce VMT or encourage the use of cars with lower per-mile carbon dioxide emissions, Massachusetts could witness a 12 percent increase in light-duty carbon dioxide emissions (versus 1990 levels) by 2010 and a 27 percent increase by 2020—an amount equal to 1.5 MMTCE of additional carbon dioxide being released to the atmosphere.[31] (These projections will be referred to throughout this report as the "base case.")

An increase of such magnitude will severely challenge Massachusetts' ability to meet its commitments under the New England / Eastern Canada Climate Change Action Plan. Should these increases in light-duty emissions occur, Massachusetts would need to achieve dramatic reductions in greenhouse gas emissions from other sectors of the state's economy over the next two decades in order to meet the plan's goals.

Thankfully, however, this path toward increasing carbon dioxide emissions from cars and light trucks is not inevitable. Public policies that require or encourage the manufacture and sale of more fuel-efficient or advanced technology cars can make a significant dent in Massachusetts' future emissions of greenhouse gases.

Approaches to Reducing Carbon Dioxide Emissions

Carbon dioxide emissions from fossil-fuel powered light-duty vehicles are determined by a) the carbon content of the fuel being used, b) the efficiency of the vehicle, and c) the number of miles the vehicle is driven. Public policies to address light-duty carbon dioxide emissions, therefore, must focus either on the use of less carbon-intensive alternative fuels, improved fuel efficiency, or a reduction in vehicle-miles traveled (VMT). A variety of policies can achieve these goals.

ZERO-EMISSION VEHICLE PROGRAM

In 1990, California adopted the Zero-Emission Vehicle (ZEV) program. The initial program was to require major automakers to sell vehicles with no tailpipe or fuel-related evaporative emissions in increasing quantities over time, beginning with 2 percent of sales in 1998 and escalating to 10 percent by 2003.

The ZEV program has been substantially modified since its initial adoption—as a result both of California's efforts to build more flexibility into the program and a legal action filed by automakers against the most recent round of ZEV regulations adopted in 2001. The California Air Resources Board (CARB) is currently in the midst of revising the ZEV rule, a process that is likely to be completed in the spring of 2003.

The modifications of the ZEV program over the last decade have transformed the program from one focused on the widespread introduction of electric vehicles to a multi-faceted program designed to promote the introduction of various types of advanced technology cars and trucks. The program has three main components:

- **Pure Zero-Emission Vehicles**—Under changes to the ZEV program proposed in March 2003, automakers would no longer face a significant requirement to produce "pure" zero-emission vehicles—those with no tailpipe or evaporative emissions. However, automakers would be required to sell approximately 250 hydrogen fuel cell vehicles nationwide under the program by 2008 in an effort to spur the development of the technology. In addition, the proposed changes call for CARB to study the current state of pure ZEV technology to determine whether to reimpose a specific numerical target for the sale of fuel-cell, battery-electric or other pure ZEVs after 2008.[32]

- **Partial Zero-Emission Vehicle (PZEV) Credits**—Automakers have the option of complying with up to three-fifths of their ZEV program obligations (in the near term) through the sale of ultra-clean conventional internal combustion engine vehicles. These vehicles must meet California's strict super-low emission vehicle (SULEV) emission standards, have zero fuel-related evaporative hydrocarbon emissions and meet other criteria. It is unknown whether vehicles qualifying for PZEV credit will have lower carbon dioxide emissions than other conventional vehicles.

- **Advanced Technology PZEVs (AT-PZEVs)**—Automakers may also choose to comply with up to two-fifths of their ZEV program obligations through the sale of partial ZEV credit vehicles that either a) run on a cleaner alternative fuels, such as compressed natural gas or, b) use advanced electric-drive technologies, such as hybrid-electric motors. While current hybrid vehicles—such as the Toyota Prius and Honda Insight—do not yet qualify for AT-PZEV credit, there is no technological reason why hybrids cannot.

Assuming that CARB's proposed March 2003 amendments are adopted in the form originally proposed, tens of thousands of clean, near-zero-emission vehicles will be on Massachusetts' roads within the next decade.

ZEV Program Impacts: Long Term

No assessment of short-term greenhouse gas emission reductions can capture the potential long-term and indirect benefits of the ZEV program in reducing carbon dioxide emissions. At its heart, the ZEV program is a "technology forcing" program—one that attempts to jump-start advanced technology vehicle development and encourage the adoption of these technologies in the mainstream auto market.

An example of the potential power of the ZEV 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' 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 tens of thousands of vehicles worldwide.[33]

The analysis below includes only those vehicles that automakers are ***required to sell*** under the ZEV program. It does not include the possibility of more widespread adoption of hybrid technologies or the development of a new and even cleaner generation of hybrids, much less the beginning of a transition to a "hydrogen economy." All of these developments are potential outcomes of the ZEV program's technology-forcing provisions, but are too speculative to be included in this analysis.

Should these developments occur, however, Massachusetts could see the dramatic reduction in transportation-related carbon dioxide emissions that will be needed to meet the region's long-term greenhouse gas reduction targets. Promoting these alternative technologies must be a major part of any long-term climate plan, and the ZEV program has proven to be the most effective way to bring about automotive technology change.

ZEV Program Impacts: Short Term

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

For example, automakers retain the option of satisfying the ZEV program's requirements by supplying a smaller number of "pure ZEVs," such as battery-electric or fuel cell vehicles. Given automakers' resistance to the development of battery-electric vehicles—and the major technological hurdles standing in the way of short-term introduction of fuel-cell vehicles—it is unlikely that automakers will take this path. The majority of vehicles certified to the AT-PZEV requirement are likely to be hybrid-electrics (although automakers may also choose to sell natural gas vehicles to comply with the AT-PZEV requirement). Because automakers are expected to make full use of the PZEV option—and because PZEVs are assumed to run on conventional fuel with no inherent improvement in carbon dioxide emissions—the substitution of PZEVs for conventional vehicles is not expected to reduce Massachusetts' contribution to global warming.

Assuming that manufacturers fulfill the entire AT-PZEV option with hybrids, and that only an insignificant number of pure ZEVs are required to be sold within the state, Massachusetts could see a 5 percent reduction in carbon dioxide emissions versus the base case by 2020—for a total reduction in emissions of about 0.4 MMTCE. (See Figure 6.)

Figure 6. Reductions in Carbon Dioxide Emissions under ZEV Program (March 2003 Proposed Revisions)

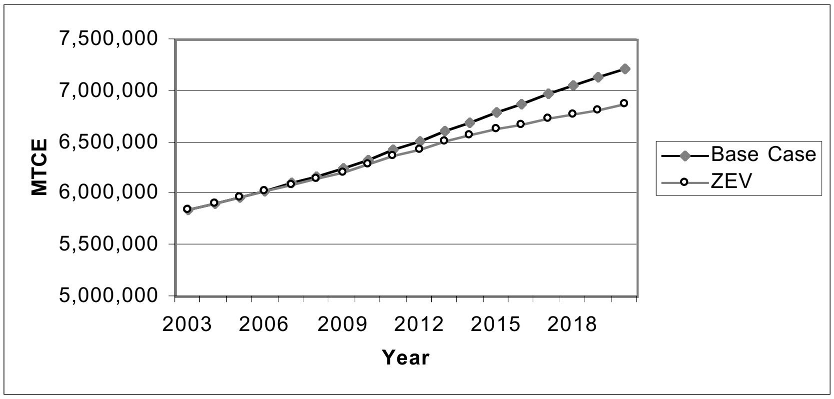


Table 2. Reductions in Carbon Dioxide Emissions under ZEV Program (March 2003 Proposed Revisions)

Year	Emissions (MMTCE)	Increase Over 1990	Increase Over Base Case
2005	5.97	5%	0%
2010	6.29	11%	-1%
2015	6.62	17%	-2%
2020	6.87	21%	-5%

CALIFORNIA ("PAVLEY") CARBON DIOXIDE LIMITS

In July 2002, California took another step toward reducing emissions from motor vehicles by adopting 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.

The California legislation (sponsored by Assemblywoman Fran Pavley and hereafter referred to as the "Pavley" standards) 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.[34]

Because the regulations that will be used to implement the Pavley standards will not be finalized until 2005, it is impossible to determine the impact of Massachusetts' eventual adoption of the standards. Much depends on how CARB chooses to interpret the "maximum cost-effective and technologically feasible" provisions of the law. However, one study has projected fleet-wide average reduction in carbon emissions of approximately 30 percent, phased in over the first 10 years of the Pavley program, based on the assumption that the regulations will spur the use of a variety of existing emission-reducing technologies.[35]

Assuming this 30 percent reduction, and a phase-in schedule consistent with the one in California, Massachusetts could experience a 10 percent reduction in light-duty vehicle carbon dioxide emissions by 2020—for a total reduction of 0.7 MMTCE. (See Figure 7, next page.)

Even under a more conservative scenario, in which CARB would require a 15 percent average reduction in new-vehicle carbon dioxide emissions by 2020, Massachusetts could still experience significant benefits. Under such a scenario, the commonwealth would likely experience a 5 percent reduction in carbon dioxide emissions from the light-duty vehicle fleet, or approximately 0.4 MMTCE. Again, the uncertainty surrounding CARB's implementation of the Pavley standards means that the benefits for that state—and for Massachusetts—could be significantly greater or less than are projected here. However, even a less-aggressive greenhouse gas reduction target under Pavley would still result in a significant improvement in carbon dioxide emissions versus the base case.

MASSACHUSETTS CASE: ZEV PLUS PAVLEY

Massachusetts' Commitment to Cleaner Cars

Massachusetts has already committed itself to the adoption of the ZEV and Pavley programs through 1990 legislation that requires the state to adopt the nation's toughest vehicle emission standards.

Massachusetts' power to adopt tougher emission standards than those in place at the federal level is rooted in federal environmental law. California was the first state in the nation to adopt specific policies related to reducing air pollution from motor vehicles. When the federal government followed suit in 1970 with passage of the original Clean Air Act, California was permitted to continue to issue its own automotive emission standards, based both on the state's regulatory history and its pressing air pollution problems.

In 1977 revisions to the Clean Air Act, other states were given the opportunity to adopt California emission standards for cars, provided that those standards are "identical" to California's standards and do not "create or have the effect of creating ... a 'third vehicle.'"[36] In other words, states have two choices when deciding how to regulate emissions from cars: they can follow the federal standards or the California standards. No state standards that would require automakers to market a wholly separate type of vehicle—a "third car"—are permitted.

In 1990, the Massachusetts Legislature moved to adopt California's Low Emission Vehicle auto emission standards. The Legislature also committed Massachusetts to the adoption of California emission standards whenever those standards are more stringent than the federal standards in place at the time:

> The department of environmental protection ... shall adopt motor vehicle emissions standards based on the duly promulgated motor vehicle emissions standards of the state of California unless, after a public hearing, the department establishes ... that said emissions standards and a compliance program similar to the state of California's will not achieve, in the aggregate, greater motor vehicle pollution reductions than the federal standards and compliance program for any such model year.[37]

Figure 7. Reductions in Carbon Dioxide Emissions Under Pavley Standards

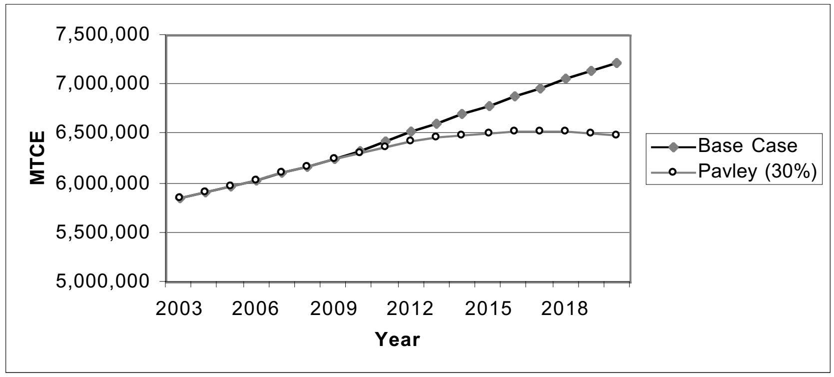


Table 3. Reductions in Carbon Dioxide Emissions Under Pavley Standards

Year	Emissions (MMTCE)	Increase Over 1990	Increase Over Base Case
2005	5.97	5%	0%
2010	6.31	11%	0%
2015	6.52	15%	-4%
2020	6.50	14%	-10%

This commitment guarantees that Massachusetts residents will have access to the cleanest cars available nationwide—including the advanced-technology vehicles made available under the ZEV program and the vehicles with lower carbon dioxide emissions that will be made available under the Pavley standards.

Assuming that Massachusetts implements both ZEV and Pavley in the same year that California begins implementation of the two programs, Massachusetts should expect to see a reduction in carbon dioxide emissions of approximately 12 percent versus the base case—for a total reduction of about 0.9 MMTCE. (See Figure 8.)

It should be noted that even these two aggressive policies combined will not bring Massachusetts in line to comply with the regional goal of returning greenhouse gas emissions to 1990 levels by 2010, or of reducing those emissions by 10 percent below

Figure 8. Reductions in Carbon Dioxide Emissions Under ZEV + Pavley Scenario

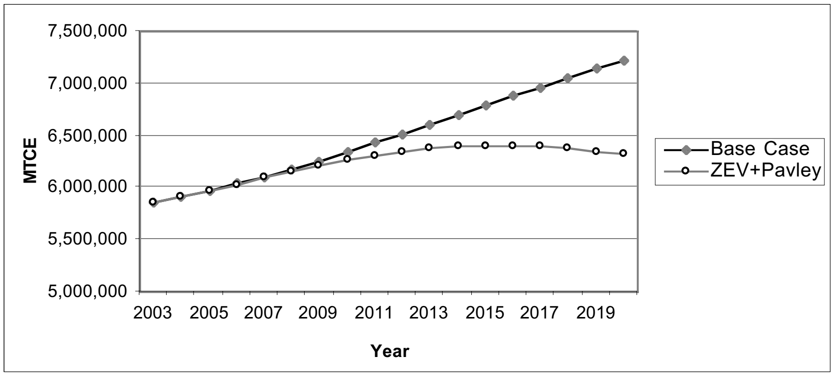


Table 4. Reductions in Carbon Dioxide Emissions Under ZEV + Pavley Scenario

Year	Emissions (MMTCE)	Increase Over 1990	Increase Over Base Case
2005	5.97	5%	0%
2010	6.26	10%	-1%
2015	6.40	13%	-6%
2020	6.33	11%	-12%

1990 levels by 2020. In large part, this is due to the late implementation timeline of the ZEV and Pavley programs, which do not begin to make a significant dent in carbon emissions until early in the next decade.

However, the long-term significance of these programs is profound. By 2015, they will put Massachusetts' light-duty transportation sector on a downward trajectory for total carbon dioxide emissions—a trend that should continue and accelerate as more advanced technology vehicles come onto the market and increasing numbers of conventional cars include Pavley-required carbon dioxide reduction technologies. The two programs also do much to promote the continued development of advanced automotive technologies—technologies that could lead to even more significant reductions in carbon dioxide releases in the years to come.

One final note: the decreases in carbon dioxide emissions shown above with ZEV/Pavley come ***despite*** the large projected increase in VMT over the next two decades. Should Massachusetts succeed in efforts to reduce the growth of VMT, the impact of the two programs will be even greater and set Massachusetts on a course toward significant long-term reductions in carbon emissions.

FEEBATES

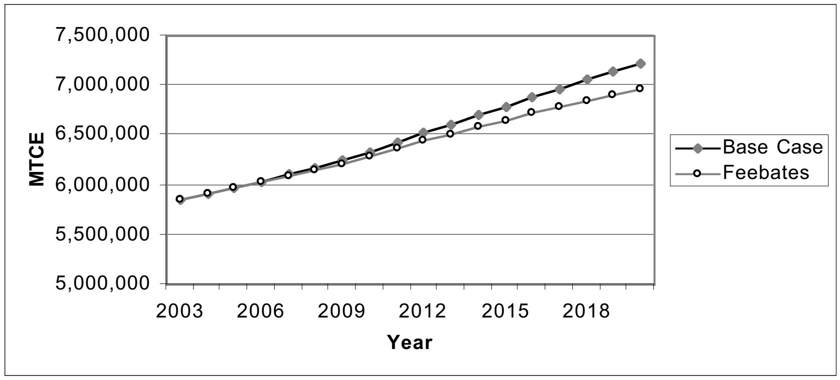
In addition to fulfilling the commonwealth's commitments to implement the nation's strongest vehicle emission standards, Massachusetts also has a series of other policy alternatives to reduce greenhouse gas emissions from motor vehicles. Many of these alternatives take the form of economic incentives to individuals who wish to purchase cleaner cars.

One form of incentive would be the imposition of fees on the purchase of vehicles with high carbon emissions, balanced by the granting of rebates to those who buy vehicles with low carbon emissions. This policy—known as "feebates"—can be implemented in a variety of ways, either by changes to the formula for assessing sales taxes on new motor vehicles, altering the assessment of annual excise taxes on all vehicles, or setting differential fees on motor vehicle registration.

A key facet of many feebate proposals is their revenue neutrality. In other words, the schedule of fees and rebates balances out so that there is no net financial gain or loss to the state. Thus, the feebates themselves are not, in their net effect, a new tax or subsidy.

In 2002, researchers with the California Energy Commission and CARB projected that a California-only feebate program of $30,000 per pound of carbon per mile would produce a 4.3 percent improvement in new-car vehicle fuel economy over baseline projections by 2010 and a 9 percent improvement by 2020. (See Table 7, page 27 for examples of how a feebate at this level would affect various types of vehicles.) For light trucks, the study projected a 5.4 percent increase in fuel economy over baseline projections by 2010 and a 9.2 percent improvement by 2020.[38]

Figure 9. Reductions in Carbon Dioxide Emissions Under Feebates Scenario



Assuming that Massachusetts would achieve similar results, the commonwealth would see a reduction of approximately 4 percent in light-duty carbon dioxide emissions—or 0.3 MMTCE—versus the base case by 2020. (See Figure 9.)

However, these projections are quite uncertain given Massachusetts' status as a small state, ambiguities about how manufacturers and consumers would respond to a state feebate program, and questions about how a feebate system in the state would be structured.

State Versus Regional or National Feebates

In 1995, researchers with the U.S. Department of Energy (DOE) studied the economic and fuel economy impacts of six national feebate scenarios. The study concluded that a national feebate based on gasoline consumption could result in a 14 percent improvement in fuel economy for cars and 11 percent for trucks over 15 years. Moreover, a national feebate of $50,000 per gallon-per-mile (GPM), the analysts projected, would yield a net annual economic benefit of more than $10 billion by the program's tenth year.[39]

However, one of the study's most important conclusions was that the majority of the benefits of feebates would come as a result of manufacturers' response to the program—not from consumers' response. Feebates, the study predicted, would make the installation of many fuel-economy technologies cost-effective for manufacturers, hastening their spread into the marketplace, but they would not have a large impact on individual consumers' choices.

This finding has important ramifications. Because Massachusetts accounts for only about two percent of vehicle sales nationwide, the creation of a feebate system here would provide only a small incentive to manufacturers. Thus, the state could—in the absence of any other factors—expect a far less significant overall fuel-economy benefit than was projected in the California study.

Table 5. Reductions in Carbon Dioxide Emissions Under Feebates Scenario

Year	Emissions (MMTCE)	Increase Over 1990	Increase Over Base Case
2005	5.97	5%	0%
2010	6.29	11%	-1%
2015	6.65	17%	-2%
2020	6.97	23%	-4%

Massachusetts could get greater results from a feebate program if it were joined by other states in the New England region or possibly by the federal government. However, other factors could also lead to a feebate program producing results similar to, or greater than, those projected in the California study.

Manufacturer and Consumer Response

The first factor is the degree to which manufacturers are assumed to channel technological innovations into improved fuel economy. The DOE study assumed that improvements in automobile technology over the 15 years of the study period would be channeled into improved fuel economy, not increased vehicle power. In the eight years since the study was published, however, fuel economy has remained stagnant while vehicle power has increased. For example, in 2001, the average vehicle was 22 percent heavier, possessed 84 percent greater horsepower, and accelerated from zero to 60 miles per hour 27 percent faster than in 1981.[40] The DOE study's authors predicted that, under a scenario in which automakers channeled improvements into increasing vehicle power, "the percent change in new-vehicle fuel economy due to feebates would likely be larger than with a constant power baseline."[41]

A second factor that suggests a Massachusetts feebate program could have a greater impact than otherwise expected is the drop in price of many technologies that could be used to improve fuel economy. Both the DOE and California studies relied on conservative assumptions about the potential for cost-effective improvements in fuel economy. Rapid advances in engines, transmissions, materials and electrical systems create the potential for automakers to offer consumers a wider choice of highly efficient vehicles. Should these vehicles be offered for sale, a feebate plan could help spur more consumers to purchase them.

Factors in Feebate Design

To a large degree, however, the success of a Massachusetts feebate program would depend on how it is structured. Policy makers considering the implementation of feebates must consider several factors:

Within Class/Cross-Class Implementation—A key issue with regard to feebates is whether the "zero point" (the level of fuel economy or carbon emissions at which neither a fee is assessed nor a rebate granted) should be calculated within or across vehicle classes. Calculating feebates within vehicle classes has the potential to cause inequities. For example, drivers of certain SUVs may receive rebates, while drivers of some compact cars that get better mileage are assessed fees. What is important in such a calculation is whether the vehicle is relatively more efficient than other vehicles in its class, so an SUV that is relatively efficient in comparison with other SUVs will be rewarded, while a compact car that is less efficient than other compact cars will be penalized.

Setting a single zero point for all light-duty vehicles, by contrast, would lead to a situation in which most light trucks pay a fee while most cars receive a rebate. The DOE study projected that this could cause a nearly immediate 4 percent increase in new-car sales and 2.5 percent decrease in new light-truck sales. The study found little impact on overall fuel economy compared to"within class" feebate scenarios.[42]

Establishing a single benchmark for carbon emissions reinforces the notion that cars, vans and SUVs should be held to the same standards for environmental impact. Traditionally, light trucks have been permitted to meet relaxed standards for vehicle emissions and fuel economy based on the presumption that most are used for commercial purposes. This distinction is no longer valid, although it may be possible to exempt some vehicles used for legitimate commercial purposes from a feebate plan. A cross-class feebate strategy may also enable Massachusetts to get significant benefits from feebates without a strong response from manufacturers—in effect, by encouraging a small percentage of consumers to switch from SUVs to more efficient cars.

Means of Measurement—As noted above, policy-makers have several benchmarks to choose from when deciding how to assess feebates. They can choose to peg the feebates to fuel economy (miles per gallon), gasoline consumption (gallons per mile), or carbon dioxide emissions.

The difference is much more than a matter of semantics, for two reasons. First, efficiency-based feebates (MPG-based) reward vehicles in a proportionally different way than consumption-based or emission-based feebates. For example, a feebate calculated based on MPG would give the same reward for an increase in fuel economy from 20 to 21 MPG as it would for an increase from 60 to 61 MPG — even though the former represents a five percent improvement in fuel economy, while the latter represents a less than two percent improvement. Consumption- or emission-based feebates, on the other hand, will tend to give greater proportional rewards to efficiency improvements at the lower end of the fuel economy spectrum. Because such a system appears to be more effective in reducing carbon dioxide emissions—and because the ZEV program already promotes the development of inherently more efficient vehicles at the upper end of the efficiency spectrum—a consumption- or emission-based feebate system would likely be preferable for Massachusetts.

Such a system would also be preferable for another reason: substantial doubt remains about the legal status of feebate systems that reward improved fuel economy. Federal law bars states from adopting regulations that are "related to fuel economy standards" and, in fact, the only other state feebate scheme that has been adopted by a legislature—Maryland's "gas guzzler / sipper tax," was declared invalid by the National Highway Traffic Safety Administration based on the federal CAFE preemption. The Maryland tax was never implemented.

A clear argument could be made—and, in fact, was made by the Maryland Attorney General—that a state's broad powers of taxation should allow it to set differential fee rates based on a vehicle's fuel economy. But with the legality of such measures uncertain, it may be more appropriate for the state to adopt a feebate program that is explicitly designed to control vehicle emissions (in this case, carbon emissions), rather than fuel economy.

Linear/Non-Linear Feebate Schedules—Because a majority of vehicles sold within each vehicle class attain roughly the same fuel economy, a plan in which feebate levels rise or fall in linear relation to carbon emissions, efficiency or gasoline consumption would provide little incentive for consumers to choose vehicles that are marginally more fuel efficient. An alternative strategy is to establish feebates that give greater proportional rewards or penalties to vehicles in the middle of the efficiency spectrum, with lesser rewards or penalties to those at the extremes. The 1995 DOE study suggested that such a non-linear approach with an average feebate level of $50,000 per GPM could approximate the fuel economy benefits of a linear feebate of twice that amount.[43]

Feebate Levels—Obviously, the level at which a feebate is set—the financial reward or penalty experienced by car-buyers when making their choice of vehicle—will have an impact on the effectiveness of the feebate system in influencing consumers' and manufacturers' behavior. But the impact may not be as great as intuition would suggest. The 1995 DOE study found that doubling the $50,000 per GPM linear feebate to $100,000 per GPM yielded only a marginal three percent improvement in fleet fuel economy versus the lower feebate level, and concluded that the most cost-effective fuel economy improvements would already be incorporated by manufacturers under the lower feebate level.

The 1995 study, however, was published before the commercial introduction of advances such as hybrid-electric vehicles. Because hybrids cost significantly more than conventional vehicles—and can deliver large gains in fuel economy—a relatively high feebate level could be more successful in driving purchases of these vehicles or in encouraging manufacturers to include hybrid drive in a greater percentage of their cars and trucks. However, these same benefits could also be attained through tax or other incentives directed specifically toward hybrids.

In sum, as long as the financial incentive / disincentive is sufficient to drive the introduction of technologies to improve fuel efficiency, a feebate is likely to be successful. Dramatically increasing the rate of the feebate may spark the introduction or more expensive—and more advanced—technologies, but other policies can also achieve the same goal while maintaining lower average feebate levels.

Massachusetts Feebate Proposals

Legislation that would create a feebate system in Massachusetts has been filed for more than a decade. This proposed feebate system differs significantly from those mentioned above.

Key facets of the Massachusetts proposal are as follows:

- The feebate would be assessed by varying the rate of the state sales tax on new motor vehicles. Vehicles with the highest fuel efficiency (as measured in MPG) would pay no sales tax, while those with the lowest fuel efficiency would pay 10 percent sales tax—double the current 5 percent rate.

- Feebate levels would be set across vehicle classes, but the Department of Revenue could consider the relative fuel efficiency of various vehicle classes in establishing feebate rates.

- No vehicle whose fuel efficiency is below the national fleet average would receive a rebate.[44]

The proposal leaves broad latitude to the Department of Revenue to establish the means by which feebates would be assessed. However, two possible scenarios show how decisions on implementation of the program might affect the level of feebates assessed. In one scenario, feebates vary in a linear fashion above and below the national fleet average fuel economy. The second scenario assumes a non-linear feebate schedule (see Table 6), in which variations in fuel economy close to the fleet average receive proportionally greater rewards or penalties. This scenario also bases the degree of feebates on fuel consumption—the inverse of miles-per-gallon fuel economy.

Applying these assumptions—and including the feebate schemes analyzed above from the DOE and California studies—the following estimated feebates would be applied to the following sample vehicles. (See Table 7.)

Table 6. Example of a Non-Linear, Sales Tax-Based Feebate

Sales Tax Rate	Fuel Economy (Miles Per Gallon)
0%	47.8 and up
1%	33.0-47.8
2%	29.0-33.0
3%	25.8-29.0
4%	24.5-25.8
5%	23.3-24.5
6%	22.2-23.3
7%	20.3-22.2
8%	18.8-20.3
9%	15.9-18.8
10%	15.9 and under

As the table above shows, a non-linear feebate along the lines of that proposed in Massachusetts would—for the majority of car buyers—result in feebates similar to those projected in the DOE study, but significantly lower than those used in the California study. By tying the feebate to the sales tax rate, the rewards and benefits of the program vary not only by fuel economy, but also by vehicle cost. In addition, the 10 percent limit on sales taxes does not allow for the very large rebates given to pur-

Table 7. Sample Feebates Under Various Scenarios[45]

Manufacturer	Model	Vehicle Type	MPG	MSRP*	Mass. (Linear)	Mass. (Non-Linear,GPM)	DOE ($50k/GPM)	California ($30k/lb. carbon)
Honda	Insight (CVT)†	Coupe	56.6	$21,280	$862.02	$1,064.00	$1,207.88	$3,893.76
Honda	Civic HX (CVT)†	Small Car	37.3	$14,710	$243.65	$588.40	$749.77	$2,416.98
Honda	Accord DX	Family Sedan	28.1	$16,600	$85.47	$332.00	$309.52	$997.78
Ford	Focus ZX3	Small Car	27.7	$13,280	$62.61	$265.60	$287.00	$925.17
Toyota	RAV4 (2WD)	SUV	26.3	$18,085	$52.73	$361.70	$187.29	$603.75
Chrysler	Concorde	Large Sedan	24.6	$23,830	$20.70	$238.30	$59.53	$191.90
Ford	Ranger (2WD)	Pick-up	24.4	$14,015	$7.82	$0.00	$38.66	$124.63
Chrysler	Voyager	Minivan	23.7	$21,220	-$15.05	$0.00	-$17.65	-$56.91
Ford	Taurus SEL	Family Sedan	23.2	$23,820	-$63.35	-$238.20	-$67.78	-$218.49
Ford	Crown Victoria Std.	Large Sedan	21.6	$24,320	-$198.35	-$486.40	-$222.76	-$718.11
Pontiac	Grand Prix GTP	Coupe	21.5	$27,045	-$230.17	-$540.90	-$233.53	-$752.82
Dodge	Grand Caravan (AWD)	Minivan	19.7	$28,470	-$424.02	-$854.10	-$446.02	-$1,437.81
Dodge	Durango (4WD)	SUV	14.3	$27,325	-$935.06	-$1,366.25	-$1,416.72	-$4,567.00
Dodge	Ram 1500 (4WD)	Pick-up	13.8	$19,125	-$684.97	-$956.25	-$1,531.14	-$4,935.83

* Manufacturer's suggested retail price; †Continuously variable transmission

chasers of ultra-efficient vehicles, or the large fees assessed to buyers of inefficient vehicles, that are possible under the DOE and California assumptions.

In short, a sales tax-based feebate in Massachusetts could be structured in such a way as to provide significant financial incentives for the purchase of cars with lower carbon dioxide emissions. Many factors—including the degree to which neighboring states adopt feebates, the response of manufacturers and consumers to the program, and the design of the program itself—will influence whether those incentives result in meaningful reductions in carbon dioxide emissions. It is reasonable to assume that, despite the small size of Massachusetts' automobile market, a well-designed feebate program can achieve significant fleet-wide emission reductions, while sending a powerful message to consumers about the value of more-efficient vehicles that release smaller amounts of greenhouse gases.

Figure 10. Reductions in Carbon Dioxide Emissions Under Feebates/ZEV/Pavley Scenario

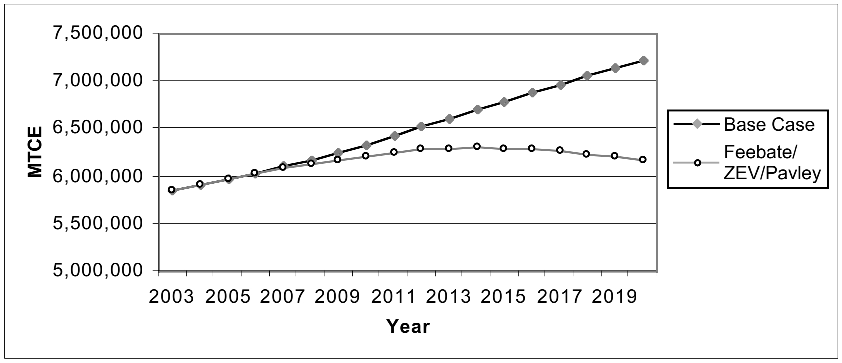


Table 8. Reductions in Carbon Dioxide Emissions Under Feebates/ZEV/Pavley Scenario

Year	Emissions (MMTCE)	Increase Over 1990	Increase Over Base Case
2005	5.97	5%	0%
2010	6.22	10%	-2%
2015	6.29	11%	-7%
2020	6.17	9%	-15%

Combined Impact with Other Policies

Estimating the impact of a feebate program implemented in conjunction with the ZEV and Pavley standards is difficult because of the overlapping nature of the carbon emission reductions driven by the feebates and the Pavley limits. Two scenarios merit consideration. In the first scenario, feebates are a temporary program to stimulate improvements in fuel economy and carbon emissions in the short-term, expiring once the Pavley standards begin to make a significant impact in 2010. Under this scenario, a short-term feebate program would yield only a marginal improvement in carbon emissions—approximately 0.01 MMTCE—by 2020. However, the feebates would generate a small, but significant, reduction in carbon emissions in the 2005-2010 timeframe—earlier than is possible under ZEV/Pavley.

A second scenario assumes the continuation of feebates concurrent with the implementation of the Pavley standards. In this case, Pavley standards are considered to be the new baseline for carbon emissions, with feebate levels calibrated upward in the 2010-2020 period to continue to act as a driver for the purchase of vehicles with lower carbon emissions. In this scenario, the impact of the feebates and Pavley are presumed to be additive.

This second scenario—with the ZEV, Pavley and feebate programs continuing until 2020—would yield a 15 percent, or 1.1 MMTCE, reduction in light-duty carbon dioxide emissions versus the base case by 2020. The addition of feebates is significant in this case, contributing approximately 0.2 MMTCE in carbon dioxide reductions versus ZEV/Pavley without feebates. (See Figure 10.)

Again, it is important to note that these results are highly uncertain and depend both on the ultimate implementation of the Pavley program and the degree to which a Massachusetts-only feebate program could match the long-term improvements in fleetwide fuel economy suggested by the California and DOE studies. Much of the uncertainty regarding the impact of feebates could be removed, however, if a regional program of feebates were to be adopted. Adoption of a regional feebate plan would also discourage Massachusetts residents from seeking to evade the law by purchasing or registering vehicles out-of-state. Finally, a regional plan would be perfectly consistent with the New England Governors/Eastern Canadian Premiers call for incentives for the purchase of advanced technology and more fuel-efficient vehicles.

Other Economic Incentives

The federal government and many states have enacted incentives—typically in the form of tax deductions or credits—for the purchase of alternative-fuel or hybrid vehicles. The federal program includes tax deductions of up to $2,000 toward the purchase of hybrid electric vehicles and tax credits of up to $2,000 for the purchase of battery-electric vehicles. Both incentives are in the process of being phased out, although President Bush has proposed new tax incentives for purchases of hybrid or fuel-cell vehicles. Other federal incentives provide significant deductions to businesses that purchase alternative-fuel vehicles for their fleets or install alternative-fuel infrastructure.[46]

In Massachusetts, the state offers businesses rebates of up to $2,000 to offset the incremental cost of purchasing an alternative fuel vehicle. No tax incentives are targeted directly at individual consumers.

A tax credit or deduction that rewards the purchase of fuel-efficient, alternative-fuel, or hybrid-electric vehicles could provide a substantial incentive for consumers to make choices that will lower their contribution to climate change—particularly if the incentive approximates the incremental cost of purchasing a cleaner vehicle. Indeed, one can imagine a tax incentive scenario that would yield similar benefits to those estimated under the Feebates scenario above.

The downside of such a program, however, is that it is not revenue-neutral. Without offsetting increases in revenue—perhaps either from fees assessed as part of a feebate program or increased gasoline taxes—it is unlikely that an incentive significant enough to influence consumer behavior will be adopted, given the current shortfall in state revenues.

CAFE STANDARDS

The imposition of federal corporate average fuel economy (CAFE) standards in 1975 has saved millions of barrels of oil and restrained what would have been an even more dramatic growth in carbon dioxide emissions from cars and trucks during the 1980s and 1990s. Increasing federal CAFE standards over the next two decades to take advantage of new automotive technology can lead to similar reductions in gasoline use—and ultimately, lower carbon dioxide emissions from vehicles in Massachusetts.

The technology to make significantly more fuel-efficient vehicles exists today. A 2001 analysis by the American Council for an Energy-Efficient Economy (ACEEE) found that improvements in automotive technology possible within the 2010-2015 timeframe could result in a 51 percent increase in average fuel economy over the entire new-car fleet at an average cost increase of 5.8 percent—much of which would be recouped over the lifetime of the vehicle in reduced fuel costs. The study posited that fleetwide fuel-economy of 36 to 41 MPG would be achievable by 2012, depending on the mix of vehicles incorporating "moderate" and "advanced" technology packages to achieve greater fuel efficiency and the penetration of a small percentage of "mild" and "full" hybrid-electric vehicles into the market.[47] (See Table 9, next page.)

Even more conservative analysts note the potential for significant improvements in vehicle fuel economy. A 2002 National Research Council report found that automakers could cost-effectively boost the fuel economy of their fleets by 12 to 42 percent, with the greatest potential increases coming in the fuel economy of light trucks. In other words, the increase in price that consumers would face for these fuel economy improvements would be more than offset by the fuel savings they would incur over the lifetime of the vehicle—even at a relatively low average fuel price of $1.50 per gallon.[49] Higher gaso-

Table 9. Estimated Improvement in Vehicle Fuel Economy With Various Technology Packages[48]

	Small Car (30.8 MPG Base)		Mid-size Car (26.2 MPG Base)		Pickup (21 MPG Base)		Minivan (22.3 MPG Base)		Std. SUV (20.3 MPG Base)	
	Price Increase	Improved MPG	Price Increase	Improved MPG	Price Increase	Improved MPG	Price Increase	Improved MPG	Price Increase	Improved MPG
Moderate Package	$ 944	43.7	$1,036	40.8	$1,515	28.7	$1,500	34.5	$1,395	34.6
Advanced Package	$1,125	48.4	$1,292	45.8	$2,291	33.8	$2,134	41.3	$2,087	40.1
Mild Hybrid	$3,118	56.3	$3,522	52.6	$4,547	39.2	$4,169	48.4	$4,002	47.4
Full Hybrid	$4,331	63.5	$5,089	59.3	$6,526	44.2	$5,818	54.6	$5,472	53.4

line prices would make even further gains in fuel economy cost effective for automakers and consumers.

Another key recommendation of the NRC report was the elimination of the distinction in CAFE standards between cars and light trucks. Since the inception of CAFE standards, light trucks have been subject to more lenient standards. But with pickups, minivans and SUVs making up an increasingly large segment of the market for passenger vehicles, such a distinction is no longer valid.

The results of the ACEEE study suggest that a unified CAFE standard of 40 MPG for cars and light trucks is attainable within the next decade. However, even assuming a more conservative course of action, in which CAFE standards increase from the current 27.5 MPG for cars and 20.7 MPG for light trucks to a unified CAFE standard of 40 MPG by 2020, Massachusetts (and the rest of the country) would see significant reductions in carbon dioxide emissions.

Under such a scenario—in which the EPA-rated fuel economy of cars increases by 3 percent per year between 2004 and 2016, and in which the EPA-rated fuel economy of light trucks increases by 4 percent annually between 2004 and 2020—Massachusetts could see a 17 percent reduction in light-duty carbon dioxide emissions versus the base case by 2020—a total reduction of 1.3 MMTCE. Light-duty vehicle carbon dioxide emissions would also be reduced to just 5 percent above 1990 levels, making an important contribution to Massachusetts' efforts to reach the goals of the Climate Change Action Plan. (See Figure 11, next page.)

Because automakers may apply many of the same technologies to comply with increased CAFE standards as they would to comply with the Pavley standards, it is very difficult to project the likely cumulative impact of the two programs. Indeed, the adoption of a 40 MPG CAFE standard would enable automakers to meet and surpass the prospective 30 percent reduction in grams-per-mile carbon dioxide emissions that is anticipated to result from the Pavley standards.

It is similarly difficult to project the cumulative impacts of CAFE standards and the ZEV program, since automakers would be permitted to take credit for the increased efficiency of hybrids and other advanced technologies in complying with their CAFE obligations. It is likely, however, that the ZEV program's emphasis on the use of less carbon-intensive fuels would lead to additional reductions

Table 10. Potential for Cost-Effective Fuel Economy Improvements[50]

Vehicle Class	Base MPG	Cost-Effective Fuel Economy	Pct. Increase	Increased Vehicle Cost	Savings from Fuel Economy
Cars					
Subcompact	31.3	35.1	12%	$502	$694
Compact	30.1	34.3	14%	$561	$788
Midsize	27.1	32.6	20%	$791	$1,140
Large	24.8	31.4	27%	$985	$1,494
Light Trucks					
Small SUVs	24.1	30.0	25%	$959	$1,460
Mid SUVs	21.0	28.0	34%	$1,254	$2,057
Large SUVs	17.2	24.5	42%	$1,629	$2,910
Minivans	23.0	29.7	29%	$1,079	$1,703
Small Pickups	23.2	29.9	29%	$1,067	$1,688
Large Pickups	18.5	25.5	38%	$1,450	$2,531

Figure 11. Reductions in Carbon Dioxide Emissions Under Increasing CAFE Scenario

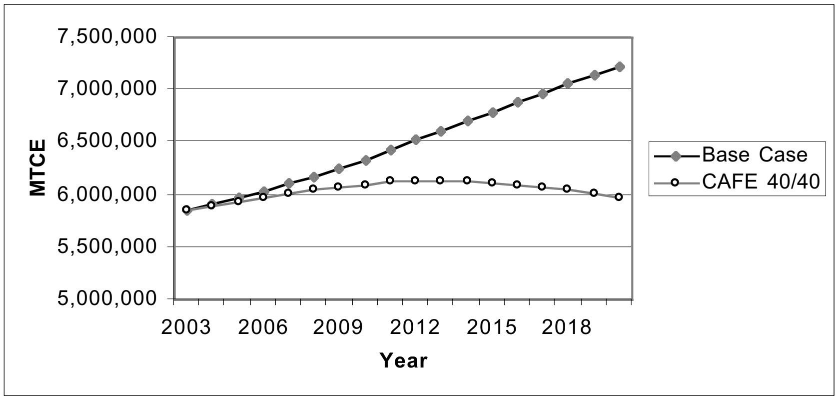


Table 11. Reductions in Carbon Dioxide Emissions Under Increasing CAFE Scenario

Year	Emissions (MMTCE)	Increase Over 1990	Increase Over Base Case
2005	5.94	5%	-1%
2010	6.10	7%	-4%
2015	6.12	8%	-10%
2020	5.97	5%	-17%

in carbon dioxide emissions above and beyond those generated by the CAFE program.[51]

Challenges of CAFE Standards

A technologically achievable increase in federal fuel economy standards would have dramatic benefits for Massachusetts as the state endeavors to limit its emissions of carbon dioxide. However, several challenges could limit the ability to implement an effective CAFE standard.

The first and most obvious challenge is that Massachusetts cannot legally implement a CAFE standard on its own—it must await leadership from Washington, D.C. Over the past decade, such leadership has not been forthcoming, either from Congress or the Clinton or Bush administrations. In fact, between 1995 and 2000, Congress explicitly barred the federal government from taking action to boost automobile fuel economy. Given the Bush administration's antipathy to significant increases in CAFE standards, it is unlikely that such an increase will be forthcoming before 2005 at the earliest.

A second challenge is posed by the increasing degree to which EPA-rated fuel economy diverges from the real-world fuel economy experienced by drivers. As noted above, the testing methods used to calculate EPA-rated fuel economy are out of date, and the trend toward higher speeds and increased urban driving threatens to reduce real-world fuel economy even further. Correcting this disparity would lead to significant increases in fuel economy—on the order of 15 to 25 percent—even if nominal CAFE standards were to remain the same. However, updating the testing methods would require an act of Congress.

Even with an increase in VMT, improvements in fuel economy standards would still have a large effect on light-duty carbon dioxide emissions in Massachusetts. However, the commonwealth cannot afford to wait for such an increase to be adopted in Washington, D.C. Massachusetts must use the tools at its disposal to bring about reductions in carbon emissions from motor vehicles, while pushing strongly for leadership at the federal level.

GASOLINE TAXES

A significant increase in the state gasoline tax could also spark reductions in carbon dioxide emissions from the light-duty fleet—both by reducing vehicle-miles traveled and spurring the purchase of more fuel-efficient vehicles. An increase in the gasoline tax could also be used to fund further efforts to limit carbon dioxide emissions.

The degree to which a change in price results in increased or decreased consumption of a good or service is called price elasticity. Estimates of short-run elasticities of fuel consumption with regard to fuel price range from approximately -0.15 to -0.5—meaning that fuel consumption decreases by 1.5 to 5 percent for every 10 percent increase in fuel price. Estimates of long-run elasticities generally range between -0.6 and -0.85 for fuel consumption, although elasticities of as high as -1.0 have been found in the U.S. in some studies.[52]

These long-term changes in fuel consumption are due to three factors: decreases in the number of vehicles overall, increases in fuel efficiency, and decreases in driving. One 1996 study of more than 40 years of U.S. data found that a 10 percent increase in fuel cost would likely lead to a 2.6 percent drop in driving long-term and a 2.3 percent increase in efficiency. Other studies have found even greater long-term efficiency improvements driven by increased fuel costs.[53]

Using these estimates of elasticity, and assuming a base per-gallon gasoline price of $1.50, a 50-cent increase in the gasoline tax could lead to a long-term 7.7 percent increase in the fuel-efficiency of driving and an 8.7 percent decrease in vehicle travel. The end result could be a drop of as much as 24 percent in vehicular fuel consumption (and, therefore, greenhouse gas emissions)—all other factors being equal. The impact of such a policy would be approximately equal to the 40 MPG CAFE standard modeled earlier in this report, and could reduce greenhouse gas emissions from light-duty cars and trucks to approximately their 2000 levels by 2020.

Other studies suggest that a gasoline tax increase may have a more limited impact.A 2002 California Energy Commission/CARB study projected that a 50-cent increase in California's gasoline tax would lead to a 4.6 percent reduction in gasoline consumption (and therefore, carbon dioxide emissions) versus base case forecasts by 2020—representing a price elasticity of demand for gasoline of only -0.145, well below the elasticities found by other studies.[54]

Imposition of a large gasoline tax increase would pose special challenges in Massachusetts, given the state's small size and the potential for some Massachusetts residents to escape the tax by purchasing their fuel in neighboring states. As of the end of 2001, Massachusetts' gasoline tax was the second-lowest in New England, higher only than that of New Hampshire.[55] However, any gasoline tax increase that was significant enough to affect consumer behavior would automatically move Massachusetts to the top of the list. Again, as is the case with feebates and other economic incentives/disincentives, the development of a coordinated regional strategy is of the highest importance.

The impact of a gasoline tax hike on carbon emissions could be magnified if the revenue generated as a result of the tax were to be directed either toward economic incentives for the purchase of more-efficient or advanced technology vehicles or to the development of alternative fuel infrastructure such as would be needed to accommodate a future shift to hydrogen fuel-cell or other advanced technology vehicles.

REPLACEMENT TIRE FUEL EFFICIENCY STANDARDS

One source of inefficiency in automobiles is the loss of energy between wheel rims and tires and between tires and the road—otherwise known as "rolling resistance." In recent decades, tire manufacturers have made great progress toward reducing rolling resistance and automakers have included fuel-efficient tires in many of their new vehicles in order to help meet their obligations under CAFE standards.[56] However, these fuel-efficient tires are not generally available to consumers replacing their original tires, reducing the "real world" fuel economy of their vehicles.

Researchers in California have estimated that substituting low rolling resistance tires for less fuel-efficient replacement tires could result in a 3 percent improvement in vehicle fuel economy.[57] Unlike other technological improvements noted in this report, this improvement would take place among all vehicles in the fleet—both new and used. And the improvements would begin virtually immediately, without having to wait for turnover of the vehicle fleet.

There is another powerful reason to promote the use of low rolling resistance tires: cost. While low-rolling resistance tires cost more, the amount of fuel they save could result in a net financial benefit to consumers within a short period of time. The California study estimated that drivers in that state would save between $87 and $260 if they chose fuel-efficient tires for their first two tire replacements.[58]

Massachusetts has several potential options for promoting the use of low rolling resistance tires—including setting fuel-efficiency standards for tires, launching a labeling program for tire fuel efficiency, incorporating fuel-efficient replacement tires in the state fleet, and creating a public education program. The clear potential benefits of low rolling resistance tires for fuel economy and greenhouse gas reduction should prompt state officials to consider policies that would encourage their use.

REDUCING VEHICLE MILES TRAVELED

While this report has focused on evaluating policies to reduce carbon dioxide emissions through improvements to automotive technology, one cannot underestimate the importance of reducing the rate of growth in vehicle miles traveled. None of the public policies evaluated above—even in combination—will reduce carbon dioxide emissions from vehicles to 10 percent below 1990 levels by 2020, the region-wide benchmark set in the Climate Change Action Plan, absent a dramatic shift in the economics of transportation (such as increased gasoline prices) or vigorous government or private action to reduce vehicle travel.

Reducing per-vehicle carbon dioxide emissions brings the Action Plan's goal of a 10 percent reduction in carbon dioxide emissions below 1990 levels within reach. Without further action to reduce per-vehicle emissions, annual VMT would have to be reduced by 9 percent below present levels by 2020. This contrasts with the 27 percent increase in VMT projected by the Mass. Highway Department for the 2003 to 2020 period.

By adopting a federal CAFE standard of 40 MPG, annual VMT could still increase by 3 percent between now and 2020 while preserving Massachusetts' ability to meet its medium-term goal of a 10 percent reduction in carbon dioxide emissions by 2020. Adoption of the ZEV and Pavley programs would require a 3 percent reduction in annual VMT to meet the goal, while adoption of a feebate program along with the ZEV/Pavley programs would require stability in annual VMT between now and 2020. (See Table 12.)

Table 12. Changes in Annual VMT Required to Meet Action Plan Goals (2003-2020, cumulative)

Base Case	-9%
ZEV/Pavley	-3%
ZEV/Pavley/Feebates	0%
CAFE	3%

Clearly, action to limit VMT growth—or to attain real decreases in VMT—must be taken in concert with actions to limit per-vehicle carbon dioxide emissions if Massachusetts is to rein in greenhouse gas emissions from the light-duty vehicle sector.

Many policies have the potential to reduce the growth in vehicle-miles traveled. Among them:

- **Basing auto insurance rates on vehicle use.** With the exception of small, low-mileage discounts on some auto insurance policies, most drivers pay the same amount to insure their vehicles whether they drive them 100 miles or 10,000 miles in a given year. Setting auto insurance rates on a per-VMT basis would reward those drivers who use their vehicles the least.

- **Gasoline taxes or VMT taxes.** A gasoline tax, as mentioned above, not only drives consumers to purchase more fuel-efficient vehicles, but also discourages unnecessary driving. A tax based on vehicle-miles traveled would have a similar effect.

- **Transit-oriented growth and community planning.** Much of the recent increase in vehicle-miles traveled is due to the spread of sprawling development patterns in which the use of a car is necessary to accomplish even the most basic of every-day tasks. Adopting concentrated land-use patterns would enable more residents to accomplish these tasks on foot or via transit, reducing the need for automobile trips.

- **Transportation infrastructure choices.** Shifting state funding away from the construction of new or expanded highways and toward the expansion and improvement of transit services would provide new choices to travelers who currently must make their trips by car.

- **Trip-reduction plans, car-pooling and demand management.** Massachusetts can maintain and expand upon programs that promote car- and van-pooling, encourage commuters to choose alternative modes of transport, and promote the implementation by employers of trip-reduction plans that reduce the number of single-passenger vehicles driven to and from worksites by employees.

It is beyond the scope of this report to evaluate these policies on their potential to reduce carbon dioxide emissions. But stabilization of VMT growth is essential to meeting the state's long-term greenhouse gas emission goals, and should be a top priority of Massachusetts decision-makers.

ALTERNATIVE FUEL VEHICLE INITIATIVES

Another option for reducing carbon dioxide emissions from vehicles is to increase the use of vehicles powered by fuels with lower per-mile carbon emissions. While alternative-fuel vehicles have made small inroads over the past decade, concerns about vehicle availability and lack of refueling opportunities, coupled with weak standards governing fleet purchases of the vehicles, have reduced the potential for fuel-shifting to make an impact on carbon emissions. Policies to improve refueling infrastructure for alternative fuel vehicles and to set higher standards for fleet purchases could resolve these problems.

EPACT and State Fleet Purchases

In 1992, the U.S. Congress passed the Energy Policy Act (EPACT), which sought to reduce the increase in gasoline use by light-duty vehicles through substitution of alternative fuels. The Act set a goal of having alternative fuels replace 10 percent of projected petroleum use in transportation by 2000 and 30 percent by 2010. The key mechanism for achieving this transition was the imposition of alternative-fuel vehicle purchasing requirements for federal and state fleets and alternative-fuel providers.[59]

The law has thus far been a failure. By 1998, alternative fuels (including oxygenates added to gasoline for air quality reasons) had replaced only about 3.6 percent of gasoline use, far short of the 10 percent goal.[60] The fleet strategy—which measures compliance based on the purchase of vehicles ***capable of running*** on alternative fuels and not the use of the fuels themselves—has also been a failure, with many of the so-called "alternative-fuel" vehicles actually being operated on gasoline.

Further, EPACT's requirement that vehicles must be capable of operating on alternative fuels to receive credit has created some perverse incentives and disincentives. For example, EPACT does not allow for credit for the purchase of hybrid-electric vehicles—which run on gasoline—even though most of the alternative flexible-fuel or bi-fuel vehicles that are purchased are also typically operated on gasoline.

While the provisions of EPACT itself may be ill-considered, the goal of the policy—to require federal and state governments to "lead by example" in the purchase of cleaner vehicles—is sound. Under the law, 75 percent of all vehicles purchased by federal and state agencies, and 90 percent of those purchased by alternative-fuel providers, must be alternative-fuel vehicles. These goals—should they be properly implemented with an eye toward real reductions in gasoline use—could be a powerful driver for future commercialization of cleaner vehicles.

Massachusetts recognized this potential long ago. In 1996, Massachusetts Gov. William Weld issued an executive order calling upon the state to go above and beyond the goals of EPACT by setting a 10 percent goal for the purchase of zero-emission vehicles. In addition, Massachusetts has attempted to comply with EPACT primarily through the purchase of dedicated alternative-fuel vehicles, such as those that run on compressed natural gas. Unlike bi-fuel or "flexible fuel" vehicles, dedicated vehicles can only run on an alternative fuel, not on gasoline.

However, Massachusetts has struggled to meet the purchasing goals set out in the executive order, largely because of the lack of availability of zero-emission vehicles such as electric cars and the lack of refueling infrastructure for fuels such as natural gas. Solving these problems will not be easy, but the state's purchasing power can still play a role both in achieving short-term reductions in carbon dioxide emissions and in helping to pave the way for future introduction of cleaner cars.

Retention of the state's dedicated alternative-fuel vehicle purchasing goals is critically important, as is expanding those goals to include the purchase of highly efficient hybrid vehicles. Maintaining those goals will help the state to "lead by example"—a key part of the Climate Change Action Plan.

Second, state government should rethink the use of inefficient SUVs for all but those purposes for which they are absolutely necessary. Gov. Romney's recent proposal to decrease the use of SUVs for state business is a positive step in this direction.

Ultimately, however, the federal government must reconsider the implementation of the EPACT goals to give states such as Massachusetts clearer direction for how to reduce the consumption of gasoline by state fleets. Should the federal government and all 50 states shift to the purchase of dedicated alternative-fuel vehicles and hybrids, the enhanced vehicle availability and refueling infrastructure that would result would be a boon to the development of cleaner cars nationwide.

Alternative Fuel Infrastructure

The state and federal experience of implementing the EPACT goals demonstrates the importance of developing refueling infrastructure for alternative-fuel vehicles. The inability to refuel at convenient times and locations has been a hindrance to the development of markets for alternative-fuel vehicles—both among government and fleet purchasers and among the general public.

The infrastructure challenge is likely to become even more acute as progress continues toward the development of fuel cell vehicles that run on hydrogen. Indeed, the greatest technical hurdle to hydrogen fuel cell vehicles may not be the operation of the vehicles themselves, but rather the ability to produce, store and distribute hydrogen in the quantities needed to operate them.

Infrastructure issues also pose another type of challenge to state and federal decision-makers. While many believe that hydrogen fuel cells are the wave of the future, the future viability of these vehicles is unproven. State and federal officials must weigh the merits of providing funding to create a "hydrogen economy" that is a decade or more away versus providing infrastructure for demonstrably cleaner vehicles—such as those that run on electricity or natural gas—in the short term.

Despite the challenges, a concerted effort to plan for alternative-fuel vehicle refueling infrastructure must be undertaken immediately if the goals of the ZEV program—and the state's long-term carbon dioxide emission reduction goals—are to be met. The first essential step is to develop a comprehensive, statewide plan for the development of alternative-fuel infrastructure.

Second, funding must be identified for implementing those infrastructure elements that are most needed in the short term. Several potential sources of funding exist. As noted above, an increase in the gasoline tax would have added benefits for carbon dioxide control if the additional revenues were devoted to the development of alternative fuel infrastructure. Some states have taken advantage of federal Congestion Mitigation and Air Quality

(CMAQ) funds to expand alternative-fuel infrastructure. Also, the state may be able to turn to natural gas and electricity suppliers to help implement an alternative-fuel plan.

Without these key investments, any shift to cleaner, alternative-fuel vehicles will be caught in a free market "Catch-22" in which individuals do not buy clean vehicles because they cannot be refueled, while potential refueling entrepreneurs do not open fueling stations because consumers are not buying the vehicles. Clearly, this is a case in which vigorous government action—both at the state and federal levels—is not only beneficial, but necessary.

Policy Findings

Attaining the reductions in carbon dioxide emissions required of Massachusetts under the Climate Change Action Plan will require the state to achieve three goals with regard to the transportation sector. The following policies would have major effects on carbon dioxide emissions from vehicles in Massachusetts.

Goal #1: Reducing carbon dioxide emissions from conventional vehicles.

The experience of stagnating CAFE standards in the 1990s has demonstrated the potential peril of delaying the introduction of carbon-reducing technologies. Because most motor vehicles remain in active use for 10-15 years, the sliding fuel economy of the light-duty fleet during the 1990s will lead to almost inevitable increases in carbon dioxide emissions from transportation in the decade to come. Thus, while it is important to look to the long term, Massachusetts must take action to get cleaner vehicles on the road immediately.

- Massachusetts should retain its commitment to adopt the nation's toughest vehicular clean air standards and move forward with implementation of the ZEV and Pavley programs, once California has adopted standards for the programs.

- Massachusetts should press strongly for the adoption of stronger federal Corporate Average Fuel Economy standards that boost the average fuel economy of the entire light-duty fleet to 40 MPG (EPA rated) by 2013.

- Massachusetts should adopt economic incentives for the purchase of light-duty vehicles with lower carbon dioxide emissions. A well-constructed feebate program—particularly if it is also adopted by other New England states—would help to achieve this goal.

- Massachusetts should adopt policies to require or promote the use of low rolling resistance tires, which improve fuel economy and reduce greenhouse gas emissions at a net financial benefit to many consumers.

- Massachusetts should establish state vehicle procurement policies that require the purchase of more fuel-efficient vehicles. Reducing the use of fuel-inefficient SUVs by state government, increasing purchases of hybrid vehicles, and establishing an average fuel economy goal for the state fleet would enable the commonwealth to fulfill the regional Climate Change Action Plan's call for state governments to "lead by example."

Goal #2: Shifting to fuels with lower per-mile carbon dioxide emissions.

Short-term improvements in the fuel economy of conventional gasoline vehicles are likely to be insufficient to meet the region's long-term climate change goals. Achieving those goals will require a shift to technologies—such as electric vehicles, "plug-in" hybrids, and hydrogen fuel cell vehicles—that produce dramatically lower carbon emissions than even the cleanest gasoline vehicles. The large hurdles that currently exist to market penetration of these vehicles will require either a major change in the economics of transportation (for example, dramatically higher gasoline prices) or concerted public and private efforts to overcome.

- Massachusetts should retain the current business tax incentive for the purchase of alternative-fuel vehicles and expand it to cover hybrid vehicles as well. The commonwealth should consider the adoption of similar tax incentives for individual consumers.

- Massachusetts should begin immediately to prepare for the introduction of advanced technology vehicles by developing a coordinated, statewide plan for alternative-fuel infrastructure. Such a plan should consider the infrastructure needs of both medium-term cleaner technologies—such as battery-electric and hybrid-electric vehicles—and the requirements of a long-term shift to a "hydrogen economy," both of which are integral to the achievement of long-term reductions in transportation carbon dioxide emissions.

- Massachusetts should retain its goals for the purchase of zero-emission and alternative-fuel vehicles for the state fleet, and continue to endeavor to comply with those goals through the purchase of dedicated alternative-fuel vehicles. The commonwealth should also provide assistance to municipal and other public fleets to help them procure such vehicles.

- Massachusetts should urge the federal government to reform the Energy Policy Act of 1992 to explicitly require the purchase of dedicated alternative-fuel vehicles. The definition of alternative-fuel vehicles in the act should also be expanded to include hybrids that displace the use of significant amounts of gasoline.

Goal #3: Reducing vehicle-miles traveled

Attaining the region's long-term climate change goals will require a significant change in the driving habits of Massachusetts residents. No vehicle—with the possible exceptions of electric vehicles and fuel-cell vehicles whose base fuel is derived from renewable sources—is completely free of carbon emissions, and the continued steady growth of VMT will ultimately undercut any reductions in carbon emissions that are achieved through efficiency or the use of alternative fuels alone.

- Massachusetts should take prudent steps to reduce the growth of vehicle-miles traveled in the state, with a goal of stabilizing year-to-year growth in VMT in the near future. Land-use policies that promote more compact development, improvements in transit infrastructure, and expansion of travel demand management programs can all help to attain this goal.

COSTS AND BENEFITS

The analysis presented in this report does not include consideration of the costs of the various policy alternatives. Some policies (such as the national feebate case mentioned above and some CAFE scenarios) may have a net positive effect for consumers, but others may have a more mixed short-run economic impact.

It is, however, vitally important to remember the potential costs—both to Massachusetts' environment and our economy—of doing nothing. Global warming poses significant threats to many mainstays of the Massachusetts economy—agriculture, tourism, fishing and real estate among them. The potential public health and human costs that could result from an increase in heat-related deaths or increased spread of tropical disease are beyond calculation. We must do what we can to reduce the anticipated effects of climate change. In addition, many of these same policies can lead to reduced emissions of pollutants that harm public health and promote the region's long-term energy security.

Massachusetts alone cannot solve global warming. But, as was demonstrated by the adoption of the regional Climate Change Action Plan, Massachusetts has a responsibility to do our share, while providing leadership in the broader effort to reduce greenhouse gas emissions. With action on climate change stalled at the federal level, it is up to us to be among those taking the first steps. By adopting policies that promote a more efficient, less carbon-intensive transportation system, Massachusetts can show the way for other New England states—and the nation as a whole—to follow.

METHODOLOGY

Estimates of carbon dioxide emissions from the light-duty fleet under the various scenarios were calculated by multiplying anticipated per-mile carbon dioxide emission factors by projected vehicle-miles traveled. All emission factors were calculated using the Argonne National Laboratories' Greenhouse Gas, Regulated Emissions, and Energy Use in Transportation (GREET) model, version 1.5a. Inputs to the GREET model were modified as described below.

VMT Projections

Vehicle-miles traveled estimates for Massachusetts from 1990 to 1992 were obtained from the Federal Highway Administration's *Highway Statistics* series. Estimates for 1993 through 2020 were obtained from the Massachusetts Highway Department.

Aggregate VMT estimates were broken down into VMT by vehicle class (cars, light-light-duty and heavy-light-duty trucks) according to national default VMT splits supplied by the EPA's MOBILE6 model. These estimates were then further broken down into estimates of VMT by vehicles of each model year, based on estimates of VMT accumulation rates presented in 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.

Separate estimates were made for the percentage of VMT that would be supplied by hybrid-electric vehicles under the ZEV program. It was assumed that these vehicles would accumulate VMT at the same rate as conventional vehicles. VMT estimates for AT-PZEV vehicles were derived from California Environmental Protection Agency, Air Resources Board, *Description and Rationale for Staff's Additional Proposed Modifications to the January 10, 2003 ZEV Regulatory Proposal*, 5 March 2003. California-specific AT-PZEV sales estimates were then compared with California vehicle sales projections derived from a spreadsheet supplied by CARB based on the 2001 ZEV amendments to arrive at the percentage of vehicle sales that would be accounted for by AT-PZEVs in each year of the program. (Note: All ZEV program projections are based on the version of the 2003 amendments proposed by CARB in March 2003, not those eventually adopted by the board.)

Emission Factors

Carbon dioxide emission factors were generated using the GREET model by modifying inputs in the following ways:

For all conventional vehicles, estimates of miles per gallon fuel economy were input into the GREET model for cars and light-duty trucks. The emission factors used were based only on vehicle operations—not emissions from the entire fuel cycle—and were based on the use of conventional gasoline and near-term technologies. Excluding carbon dioxide emissions from feedstock and fuels serves to understate the total contribution of conventional vehicles to global climate change. However, because Massachusetts supplies an extremely small percentage of the nation's fossil fuels, excluding feedstock and fuels provides a more accurate glimpse of in-state carbon emissions from conventional vehicles. Hybrid emission factors were based on near-term technologies for hybrid vehicles powered with federal reformulated gasoline.

Rebound Effects

Research has shown that improved vehicle fuel economy often results in an increase in vehicle-miles traveled. By reducing the marginal cost of driving, fuel economy standards and other 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.[61]

To account for this effect, carbon dioxide reductions in each of the scenarios were discounted by 20 percent. This discount may overestimate the size of the rebound effect for a carbon-based feebate program or Pavley standards, since the reductions in carbon dioxide emissions called for under those programs do not require explicit improvements in vehicle fuel economy.

Mix Shifting

One important factor not considered in any of the scenarios is the degree to which the policies studied result in shifts in the mix of vehicles on the road. Clearly, policies such as feebates have the potential not only to bring about changes in carbon emissions from individual cars and light trucks, but also to cause some consumers to opt to purchase a car rather than a truck.

Mix shifting effects can be complex. For example, the difference in CAFE standards for cars and light trucks (along with differences in safety and emissions standards) is credited in part for the virtual elimination of the traditional station wagon and its replacement by the minivan and later the SUV. Lax standards for minivans and SUVs encouraged automakers to move consumers into these more-profitable types of vehicles, which could be classified as "light trucks." Presumably, changing to a unified CAFE standard for both cars and light trucks could eliminate some of these incentives.

It is beyond the scope of this study to project how the complex interaction of financial incentives, regulatory requirements and other factors might influence consumers' vehicle choices, and we encourage further study of this topic. In all scenarios, however, any incentive for mix shifting would appear to be in the direction of persuading consumers to shift from light trucks to cars. These incentives—were they to be included—would likely suggest even greater reductions in carbon dioxide emissions resulting from the policies analyzed above.

Scenario Assumptions

- **Base Case scenario**—Assumes the phase-in of a 1.5 MPG increase in EPA-rated CAFE standards for light trucks between 2005 and 2007. Otherwise, the scenario assumes no improvement or degradation in "real-world" average fuel economy.

- **ZEV scenario—**Assumes the Massachusetts implementation of the ZEV program proposed by CARB staff in March 2003, with implementation beginning in 2005 and compliance similar to that projected by CARB for California.

- **Pavley scenario—**Assumes the linear phase-in of a 30 percent reduction in fleet-average carbon dioxide emissions for cars and light trucks over an 11-year period from 2009 to 2019, with stability after 2019. This estimate is highly uncertain and will remain so until CARB establishes regulations implementing the Pavley program in 2005.

- **CAFE scenario—**Assumes the linear phase-in of a 40 MPG (EPA rated) CAFE standard beginning in 2004 and ending in 2016 for cars and 2020 for light trucks. "Real world" mileage estimates were derived from EPA-rated CAFE standards by reducing the EPA-rated standards by 15 percent for light trucks and 12 percent for cars. The 12 percent figure for cars was chosen to acknowledge the slight degree to which fuel economy in cars has historically exceeded CAFE standards.

- **Feebates scenario—**Assumes the linear phase-in, beginning in 2004, of a 4.3 percent increase in car fuel economy by 2010 and a 9 percent increase by 2020, along with a 5.4 percent increase in light truck fuel economy by 2010 and a 9.2 percent increase by 2020 versus baseline fuel economy levels. The baseline was assumed to include the 1.5 MPG proposed increase in CAFE standards for light trucks scheduled for 2005-2007.

- **ZEV + Pavley scenario—**Assumes that conventional vehicles (i.e. non-AT-PZEV vehicles) achieve the same grams-per-mile carbon dioxide emission levels as projected under the Pavley scenario above, and that AT-PZEV vehicles achieve the same emission levels as in the ZEV scenario above. Because automakers may use ZEV and AT-PZEV vehicles toward achieving the Pavley fleet average limits for carbon dioxide emissions, this method may slightly exaggerate the combined benefits of the two programs. However, the inclusion of AT-PZEVs in the calculation could lead to greater reductions in carbon emissions being considered economically and technologically feasible. This estimate, therefore, is likely to be at the upper end of the range of expected benefits from the current ZEV program and a Pavley standard that requires 30 percent reductions in fleet-wide emissions, as assumed above.

- **ZEV+Pavley+Feebates scenario—** Assumes that feebate levels are calibrated to achieve the same percentage reductions versus baseline levels as in the Feebate scenario above. However, the baseline in this case includes the projected 30 percent reduction in carbon dioxide emissions anticipated to be required by Pavley. In actuality, this case would require feebate levels set high enough to encourage fuel economy improvements that go above and beyond the Pavley goals. As with the ZEV+Pavley scenario above, the emission reductions projected under this scenario are likely to be at the upper end of what is achievable under this combination of programs.

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, *Climate Change and Massachusetts*, Office of Policy, Planning and Evaluation, September 1997.

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

5. See note 3.

6. See note 4.

7. See note 3.

8. See note 4.

9. Ibid.

10. See note 3.

11. Because greenhouse gases have varying potentials to contribute to climate change, greenhouse gas emissions are typically presented using one of two measurements: metric tons of carbon dioxide equivalent (MTCDE) or metric tons carbon equivalent (MTCE). In subsequent references in this report, we will use metric tons of carbon equivalent (MTCE) as the unit of measurement. To convert carbon emissions to carbon dioxide emissions, one can multiply MTCE by 11/3, since carbon is 3/11ths of the molecular weight of carbon dioxide.

12. U.S. Environmental Protection Agency, *Massachusetts Greenhouse Gas Emissions and Sinks Inventory: Summary*, downloaded from yosemite.epa.gov/oar/globalwarming.nsf, 24 January 2003.

13. See note 12. Does not include non-energy related greenhouse gas emissions from waste, agriculture, industry or land use.

14. United Nations, Department of Economic and Social Affairs, Statistics Division, *Millennium Indicators Database*, downloaded from millenniumindicators.un.org/unsd/mi/mi_series_results.asp?rowID=576, 24 January 2003. Note: many former Soviet and Yugoslav republics did not report their emissions separately in 1990. Based on these countries' 1992 emissions, Massachusetts would have ranked 41st in the world.

15. Including former Eastern Bloc republics' 1992 emissions would drop the ranking to 67th.

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

17. Ibid.

18. Ibid.

19. Federal Highway Administration, *Highway Statistics Series*, years 2001 and Summary to 1995, table vm-2.

20. Values for 1980-1992 from Federal Highway Administration, *Highway Statistics Series*, years 2001 and Summary to 1995, table vm-2. Values for 1993-2001 supplied by Massachusetts Highway Department.

21. Stacy C. Davis, Susan W. Deigel, Center for Transportation Analysis, Oak Ridge National Laboratory, *Transportation Energy Data Book: Edition 22*, September 2002, Chapter 7.

22. U.S. Environmental Protection Agency, *Light-Duty Automotive Technology and Fuel Economy Trends: 1975 Through 2001*, September 2001. 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 and EPA has begun to include adjusted figures in its reporting of fuel economy trends. In this report, all discussions of vehicle fuel economy will refer to "real world" efficiency levels rather than "EPA rated" levels, unless otherwise noted.

23. It is probable that the shift toward more urban driving would produce an even stronger negative drag on fuel economy in an urbanized state such as Massachusetts. According to 2001 figures, 83 percent of all vehicle-miles traveled in Massachusetts were driven on urban roads and highways, compared to 60 percent nationally. Source: Federal Highway Administration, *Highway Statistics 2001*, Table vm-2.

24. U.S. Environmental Protection Agency, *Light-Duty Automotive Technology and Fuel Economy Trends: 1975 Through 2001*, September 2001.

25. Ibid.

26. Ibid.

27. 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.

28. Northeast States for Coordinated Air Use Management, Massachusetts Executive Office of Environmental Affairs, Massachusetts Division of Energy Resources, *Massachusetts 1990 Greenhouse Gas Inventory*, December 1996.

29. See "Methodology"

30. Federal Highway Administration, *Highway Statistics Series*, years 1992 and 2001, tables mv-1 and mv-9.

31. This includes the recent proposed increase in federal CAFE standards for light trucks.

32. California Environmental Protection Agency, Air Resources Board, *Description and Rationale for Staff's Additional Proposed Modifications to the January 10, 2003 ZEV Regulatory Proposal*, 5 March 2003. At a March 27-28, 2003 public hearing, CARB delayed a decision on this staff proposal, possibly to reconsider the reinstatement of a significant requirement for "pure" zero-emission vehicles in the program. Due to deadline considerations, however, any subsequent changes in the proposal were unable to be included in this report.

33. The reasons behind the lack of market success of the EV-Plus, EV1 and similar electric vehicles are complex, and have much to do with automakers' failure to properly market their vehicles to the public. For a more detailed discussion of this issue, please see Tony Dutzik, MASSPIRG Education Fund, *Ready to Roll: An Assessment of Massachusetts' Preparedness for the Zero Emission Vehicle Program*, March 2002.

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

35. M.J. Bradley and Associates, *Survey and Evaluation of State-Level Activities and Programs Related to Climate Change*, 18 October 2002, prepared for the Natural Resources Defense Council Climate Center. The 30 percent estimate—while highly uncertain—appears reasonable given the potential for near-term carbon dioxide emission reductions from light-duty vehicles. For example, technological changes that would bring cars and light-trucks to a unified CAFE standard of 40 MPG would result in per-mile carbon dioxide reductions of approximately 31 percent for cars and 49 percent for light trucks versus 2002 levels according to the GREET model. Technologies to achieve these improvements either exist today or will be available soon. (See "CAFE Standards," page 29.)

36. 42 U.S.C. Sec. 7507

37. 111 M.G.L. 142K

38. California Energy Commission and California Air Resources Board, *Staff Draft Report: Task 3: Petroleum Reduction Options*, March 2002.

39. U.S. Department of Energy, Office of Policy, *Effects of Feebates on Vehicle Fuel Economy, Carbon Dioxide Emissions, and Consumer Surplus*, February 1995.

40. See note 24.

41. See note 39.

42. Ibid.

43. Ibid.

44. Massachusetts House Bill 1969, 2003 legislative session.

45. MPG estimates based on 2003 model year figures from U.S. Department of Energy, U.S. Environmental Protection Agency, *2003 Model Year Fuel Economy Guide*, and assume 55 percent city driving and 45 percent highway driving. MSRP based on base estimates from automakers' Web sites. Real vehicle prices may vary. All feebate estimates based on "zero point" corresponding to the 2003 light-duty fleet average fuel economy reported by DoE/EPA. Revenue neutrality was not accounted for in this analysis.

46. U.S. Department of Energy, *Alternative Fuel Vehicle Fleet Buyer's Guide: Incentives, Regulations, Contacts: Federal*, downloaded from www.fleets.doe.gov, 26 February 2002.

47. John DeCicco, Feng An, Marc Ross, *Technical Options for Improving the Fuel Economy of U.S. Cars and Light Trucks by 2010-2015*, American Council for an Energy-Efficient Economy, July 2001.

48. Ibid.

49. Transportation Research Board, National Research Council, *Effectiveness and Impact of Corporate Average Fuel Economy (CAFE) Standards*, 2002, 66-67.

50. Ibid. Based on average scenario with 14-year payback and assuming that consumers will demand a 12 percent rate of return on any added investment in fuel economy. This assumption as to rate of return explains why the cost and savings columns are not equal.

51. The CAFE program also allows manufacturers to take extra credit for sales of alternative-fuel vehicles—allowing them to increase their fleets' average fuel economy by up to 1.2 MPG for compliance purposes and reducing the impact of the CAFE standard for the rest of their fleet. For example, in 1999, the average fuel economy of gasoline-powered Ford trucks was 19.8 MPG (EPA rated). Credits for the sales of flexible fuel vehicles pushed Ford's light-truck fuel economy to 20.74 MPG, just over the 20.7 MPG CAFE standard. However, the vast majority of flexible fuel vehicles rarely operate on the alternative fuel, with most operating on standard gasoline. As a result, the

alternative-fuel CAFE credit scheme has actually led to a modest ***increase*** in gasoline consumption and greenhouse gas emissions over the entire vehicle fleet. SOURCE: U.S. Department of Transportation, U.S. Department of Energy, U.S. Environmental Protection Agency, *Report to Congress: Effects of the Alternative Motor Fuels Act on CAFE Incentives Policy*, March 2002.

52. Victoria Transport Policy Institute, "Transportation Elasticities: How Prices and Other Factors Affect Travel Behavior," *Online TDM Encyclopedia*, downloaded from www.vtpi.org/tdm/tdm12.htm, 11 March 2003.

53. 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.

54. See note 38.

55. U.S. Congressional Budget Office, *Reducing Gasoline Consumption: Three Policy Options*, November 2002.

56. Chris Calwell, et al, *California State Fuel-Efficient Tire Report, Volume II*, California Energy Commission, January 2003.

57. Ibid.

58. Ibid.

59. U.S. General Accounting Office, *Energy Policy Act of 1992: Limited Progress in Acquiring Alternative Fuel Vehicles and Reaching Fuel Goals*, February 2000.

60. Ibid.

61. See notes 53 and 59.