Cars and Global Warming

Policy Options For Rhode Island to Reduce Global Warming Pollution from Cars and Light Trucks

Elizabeth Ridlington
Tony Dutzik
Matt Auten

Rhode Island Public Interest Research Group
Education Fund

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Executive Summary

Rhode Island could significantly limit its contribution to global warming over the next two decades by implementing two policies to reduce carbon dioxide pollution from cars and light trucks.

Global warming poses a serious threat to Rhode Island's future. Scientists project that average temperatures in Rhode Island could increase by 1° to 10° F over the next century if no action is taken to reduce emissions of global warming gases—potentially leading to coastal flooding, beach erosion, increased air pollution and heat related deaths, and a host of other impacts on Rhode Island's environment, public health and economy.

Controlling global warming emissions from the transportation sector—and particularly cars and light trucks—is essential to meeting the goals set by the Conference of New England Governors and Eastern Canadian Premiers in 2001 of reducing global warming pollution to 1990 levels by 2010 and to 10 percent below 1990 levels by 2020.

The transportation sector is the largest source of global warming pollution in Rhode Island, responsible for over one third of the state's emissions. Cars and light trucks—such as pickups, minivans and SUVs—are the most important sources of global warming emissions in the transportation sector, responsible for about two-thirds of all transportation sector emissions and about one-quarter of Rhode Island's total emissions of global warming gases.

A number of public policies can reduce the contribution of cars and light trucks to global warming and help Rhode Island meet its commitments.

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

- The stagnation in federal corporate average fuel economy (CAFE) standards for cars and light trucks, the recent shift toward greater use of less fuel-efficient SUVs, and increasing vehicle travel (to 23 million miles per day) have put Rhode Island on a course toward dramatically increased emissions of carbon dioxide from transportation over the next two decades.

Rhode Island has already taken an important first step to reducing greenhouse

gas emissions from cars and trucks by adopting the California Clean Cars Standard.

- The Clean Cars Standard (also known as the "Zero Emission Vehicle" or "ZEV" program)—which has been adopted, or is in the process of being adopted, by California and seven northeastern states – 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 will lead to light-duty carbon dioxide emission reductions of about 1.2 percent below projected levels by 2020.

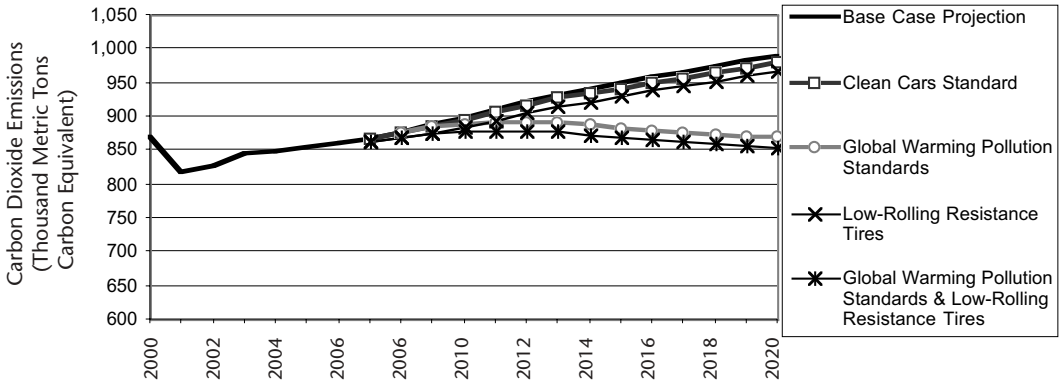
Rhode Island can achieve more significant reductions in its carbon dioxide emissions by adopting global warming pollution standards for vehicles.

- California's forthcoming standards on global warming emissions from automobiles (also known as the "Pavley" standards for their original legislative sponsor, Assemblywoman Fran Pavley) could produce significant reductions in vehicle carbon dioxide emissions. Adoption of a parallel program in Rhode Island taking effect in model year 2009 would reduce carbon dioxide emissions from cars and light trucks by about 12 percent below projected levels by 2020 at a net economic benefit to the state.

Further, the state could reduce emissions sooner and more dramatically by requiring the sale of low-rolling resistance replacement tires.

- Automakers typically equip new cars with low-rolling resistance tires, but replacement tires, which have higher resistance, cause the vehicle to be less efficient, and therefore increase carbon dioxide emissions. Enacting global warming pollution standards for vehicles and requiring that replacement tires have low rolling resistance would reduce carbon dioxide emissions by light-duty vehicles in Rhode Island by 14 percent below projected levels by 2020. Low-rolling resistance tire standards would also save consumers money by reducing fuel costs.

Fig. ES-1. Estimated Rhode Island Carbon Dioxide Emissions from Cars and Light Trucks, 2000-2020, Under Policy Scenarios



Even with these three programs in place, carbon dioxide emissions from cars and light trucks in 2020 would be just slightly lower than emissions in 2000 because of a large projected increase in vehicle travel. Thus, Rhode Island will likely need to adopt additional policies to reduce emissions from the transportation sector if it wishes to achieve the regional goal of reducing overall global warming emissions to 10 percent below 1990 levels by 2020.

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

- In 2005, Rhode Island should commit to adopting vehicle global warming emission standards identical to those that are being adopted by the state of California. To ensure the standards take effect in model year 2009, Rhode Island must draft the regulations by the end of this year.
- Requiring the use of low-rolling resistance tires would reduce global warming pollution from all vehicles once replacement tires are installed.
- Rhode Island should adopt the programs recommended by the stakeholder group—such as energy efficiency standards for appliances, new incentives for the purchase of vehicles with lower global warming emissions, "smart growth" policies that reduce vehicle travel, mass transit improvements and other measures—to reduce global warming emissions.

Introduction

In 2001, Rhode Island, 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 global warming gases over the next two decades and even greater reductions in the future.

As the first step to meeting its commitment, Rhode Island initiated the Greenhouse Gas Stakeholder Process. Representatives of business, government, academia, and the nonprofit sector gathered to develop a policy roadmap for Rhode Island to achieve its global warming emission reduction goals.

In July 2002, the stakeholders issued their recommendations, a package of 52 policies that could be adopted at the state, regional and federal level that would stabilize and reduce Rhode Island's global warming emissions in the decades to come. The recommendations cover every aspect of energy use in Rhode Island, including transportation.

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

The technology exists to reduce emissions from cars and light trucks, the largest source of transportation emissions. The tools to make less-polluting cars and trucks can be implemented at little cost—or even a 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 emission reduction goals.

Three transportation policies could bring these new technologies to Rhode Island's roads and help reduce global warming pollution from cars and light trucks. California's Clean Cars Standard, endorsed by the stakeholders after their initial round of recommendations, sets sales requirements for hybrid-electric and other clean vehicles. Two significant policies not included by the stakeholders are adoption of California's forthcoming tailpipe emission

standards for carbon dioxide and using low-rolling resistance replacement tires.

Rhode Island has adopted the Clean Cars Standard, which originated in California but has been adopted by other states including Massachusetts, Connecticut, New York and New Jersey. It requires that a percentage of vehicles sold in Rhode Island in coming years be advanced-technology vehicles such as hybrids, which, though they are designed to have lower emissions of smog-forming and toxic air pollutants, also have modest global warming benefits.

Now it is time for Rhode Island to adopt limits on vehicle global warming pollution. California's forthcoming standards for vehicle global warming emissions will lead to even greater progress toward realizing the promise of new technologies to reduce the impact of our transportation system on the climate.

This report documents the impact that adoption of vehicle global warming standards and a low-rolling resistance tire sales requirement could have for reducing global warming pollution from motor vehicles in Rhode Island. But it also documents the challenge the state faces in reining in emissions from the transportation sector. Even with adoption of these programs, Rhode Island will still need to take additional steps to curtail global warming pollution from transportation and achieve its overall climate protection goals.

Global Warming and Rhode Island

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 Rhode Island.

Causes of Global Warming

Global warming is caused by human activity that exacerbates 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. The greenhouse effect is necessary for the survival of life; without it, temperatures on earth would be too cold for humans and other life forms to survive.

But human activities, particularly over the last century, have changed the atmosphere and intensified the greenhouse effect by releasing pollution that traps more of the sun's heat near the earth's surface. This pollution comes largely from cars, power plants, factories and homes when we burn fossil fuels such as coal, oil and gas—as well as from other human and natural processes.

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

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

Range of 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 Rhode Island and around the world. There is also little doubt that global warming could lead to dramatic disruptions in our economy, environment and way of life.

Over the last century, for example, the average temperature in Providence has increased by 3.3° F.[3] The average temperature of surface water in Narragansett Bay has risen 3°F since 1950.[4] Meanwhile, precipitation has increased by 20 percent.[5]

Should current emission trends continue, temperatures in Rhode Island could increase by 1°F to 10°F by 2100.[6] Others estimate that a 1.8° F increase in average temperature could occur New England-wide as soon as 2030, with a 6°F to 10°F increase over current average temperatures by 2100.[7]

Precipitation levels also could change. Scientific models suggest that precipitation may increase in every season, most significantly in winter by 25 percent.[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, resulting in additional threats to respiratory health, such as aggravated cases of asthma.[9]
- Increased coastal flooding and beach erosion due to higher sea levels, with sea levels projected to rise by as much as 30 inches over the next century. Rhode Island has over 400 miles of heavily populated shoreline that could be affected by rising sea levels.[10]
- Increases in toxic algae blooms and "red tides," resulting in fish kills and contamination of shellfish.[11]
- Shifts in populations of fish, shellfish, and other aquatic species due to changing water temperatures and changes in the composition of coastal estuaries and wetlands.[12]
- Increased spread of mosquito and tick-borne illnesses, such as Lyme disease, West Nile virus and Eastern equine encephalitis.[13]
- Increased risk of heat-related illnesses and deaths.[14]
- Declines in freshwater quality due to more severe storms, increased precipitation and intermittent drought, potentially leading to increases in waterborne disease.[15]
- Increased spread of exotic pests and shifts in forest species—including the loss of hardwood trees responsible for vibrant fall foliage displays.

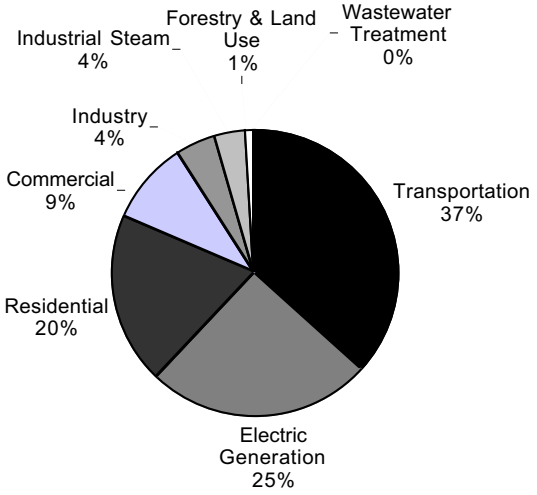
The likelihood and severity of these potential impacts is difficult to predict. But this much is certain: climate changes such as those predicted by the latest scientific research would have a dramatic, disruptive effect on Rhode Island's environment, economy and public health—unless immediate action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

Global Warming Emissions in Rhode Island

Emissions of global warming gases in Rhode Island increased by 14 percent between 1990 and 2000, to roughly 3,600 thousand metric tons carbon equivalent (thousand MTCE, see note on units page 13).[16]

The transportation sector is responsible for approximately 37 percent of Rhode Island's contribution to global warming. (See Fig. 1.) Cars and light trucks—such as pickups, minivans and SUVs—are the most important sources of global warming pollution within the transportation sector, responsible for about two-thirds of all transportation-sector emissions and about one-quarter of Rhode Island's total emissions of global warming gases.[19]

Fig. 1. Rhode Island Sources of Global Warming Emissions[20]



Other Global Warming Pollutants

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

- **Methane** – Methane gas is likely the second-most important contributor to global warming in Rhode Island. Cars and light trucks produce methane in their exhaust, but it is thought that they are only minor emitters of methane and that emissions will be reduced in the future through improved emission control systems.[17]
- **Nitrous Oxide** – Nitrous oxide is also produced in automobile exhaust, with mobile sources estimated to contribute about 13 percent of U.S. nitrous oxide emissions in 2002.[18] As with methane emissions, improved emission control measures may reduce nitrous oxide emissions in the future.
- **Hydrofluorocarbons (HFCs)** – HFCs are extremely potent global warming gases, yet tend to be released in only very small quantities. HFCs are typically used as coolants in vehicle air conditioning systems and can escape from those systems into the environment.
- **Black carbon** – Black carbon, otherwise known as "soot," is a product of the burning of fossil fuels, including diesel fuel used in heavy-duty trucks and a small percentage of light-duty vehicles. Recent research has suggested that, because black carbon absorbs sunlight in the atmosphere and on snow and icepack, it may be a major contributor to global warming, perhaps second in importance only to carbon dioxide. Research is continuing on the degree to which black carbon emissions contribute to global warming.

The Regional Climate Change Action Plan and Rhode Island's Climate Change Reduction Efforts

Recognizing the threat global warming poses to Rhode Island—as well as the opportunity for the state to make a significant contribution to reducing global warming emissions—in 2001, Rhode Island's governor joined with other New England governors and premiers of eastern Canadian provinces in adopting a regional Climate Change Action Plan.

The plan set goals for the region to stabilize, and ultimately reduce, its emissions of global warming gases to the atmosphere. In the short term, the plan calls for regional global warming 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 global warming emissions sufficient "to eliminate any dangerous threat to the climate"—a level of reduction estimated by scientists at 75 to 85 percent below present-day levels.[21]

The plan also acknowledged the importance of the transportation sector to any effort to reduce overall global warming emissions, and committed the region to attempt to "slow the growth rate of transportation emissions in the near future."[22] 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.[23]

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

During the past three years, Rhode Island has reinforced its commitment to achieving the regional goals and has begun to develop a plan designed to achieve them. The Rhode Island Department of Environmental Management and the State Energy Office initiated a public process to develop a list of recommended actions Rhode Island could take to reduce its global warming emissions. The extensive stakeholder process has involved representatives from business, government, academia and the nonprofit sector. They suggested a list of 52 programs and policies to reduce the state's contribution to global warming from all sectors of the economy, including transportation, land use, building and facilities use, electricity generation, and waste management.

A Note on Units

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

In this report, we use units of "carbon equivalent" – the amount of carbon that would need to be released to create a similar global warming effect. Other documents communicate emissions in terms of "carbon dioxide equivalent." To translate the carbon equivalent to carbon dioxide equivalent, one can simply multiply by 3.66.

Rhode Island has already implemented some of the programs endorsed by the stakeholders. One of the policies supported by the stakeholders is a renewable energy standard, enacted in June 2004, which will increase the percentage of electricity used in the state that is generated by clean, renewable sources which have zero or low global warming emissions.

By the group's analysis, implementation of the in-state policy options endorsed by all the stakeholders will bring the state close but not all the way to meeting its regional 2020 emissions-reduction target. Additional in-state policies, particularly in the transportation sector, will be needed. Further, implementation of programs has lagged, and thus adoption of additional policies that are cost-effective is especially important.

One additional program Rhode Island has recently adopted is the California Clean Cars Standard to reduce emissions of toxic and global warming gases from vehicles (the benefits of this program will be discussed in the following section on "Tools to Reduce Global Warming Emissions from Cars and Light Trucks"). Two additional programs that Rhode Island should adopt are global warming pollution standards for vehicles and low-rolling resistance tire requirements.

Transportation and Global Warming: A Primer

A gallon of gasoline contains a set amount of carbon, nearly all of which is released to the atmosphere when it is burned. Some of the carbon is released in the form of hydrocarbons, carbon monoxide, and particulate matter; most of it is released in the form of carbon dioxide. For each gallon of gasoline burned in a vehicle, over 19 pounds of carbon dioxide (or approximately 5 pounds of carbon) is released to the atmosphere. In addition, the consumption of gasoline creates significant additional "upstream" emissions of carbon dioxide resulting from the extraction, transportation, refining and distribution of the fuel. Other fuels have greater or smaller amounts of carbon in a gallon (or its equivalent).

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

1. Drive more efficient vehicles.
2. Reduce the number of miles traveled.
3. Switch to fuels with a lower carbon content.

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

The Transportation Challenge

The challenge of reducing global warming emissions from cars and trucks is formidable, and three recent trends in the transportation sector make the challenge of reducing global warming emissions in Rhode Island even greater.

Increasing Vehicle Miles Traveled

Rhode Islanders are traveling more miles in their cars and light trucks than ever before. Between 1990 and 2003, the number of vehicle-miles traveled (VMT) annually on Rhode Island highways increased from 7.4 billion miles to 8.4 billion miles a year, or over 23 million miles a day—an increase of 14 percent.[24]

Stagnating Fuel Economy

The imposition of federal Corporate Average Fuel Economy (CAFE) standards beginning in 1975 led to dramatic improvements in the fuel efficiency of American cars and light duty trucks. The CAFE standards required a gradual increase in fuel economy during the 1970s and 1980s, topping out at an average fuel economy for new cars of 27.5 miles per gallon (MPG) by 1990 and 20.7 MPG for light trucks by 1996.[26] (The National Highway Traffic Safety Administration recently increased the light truck standard to 22.2 MPG, to be achieved by model year 2007.)

In the decade-and-a-half following enactment of the CAFE standards, the "real world" fuel economy of passenger cars nearly doubled—from 13.4 MPG in 1975 to 24.0 MPG in 1988. Similarly, light trucks experienced an increase in real-world fuel economy from 11.8 MPG in 1975 to 18.3 MPG in 1987.[27]

However, the momentum toward more fuel efficient cars has not only stalled since the late 1980s, but it has actually reversed. Indeed, in many cases, Americans get fewer miles per gallon from their new vehicles today than they did during the Reagan administration.

Until recently, the federal government had refused to increase CAFE standards for more than a decade, and changes in driving patterns—including higher speeds and increased urban driving—have led to a real-world decrease in fuel economy. An EPA analysis of fuel economy trends found that the average real-world fuel economy of light-duty vehicles sold in 2003 was lower than the average fuel economy of vehicles

Fig. 2. Rhode Island VMT Increased 14 Percent between 1990 and 2003[25]

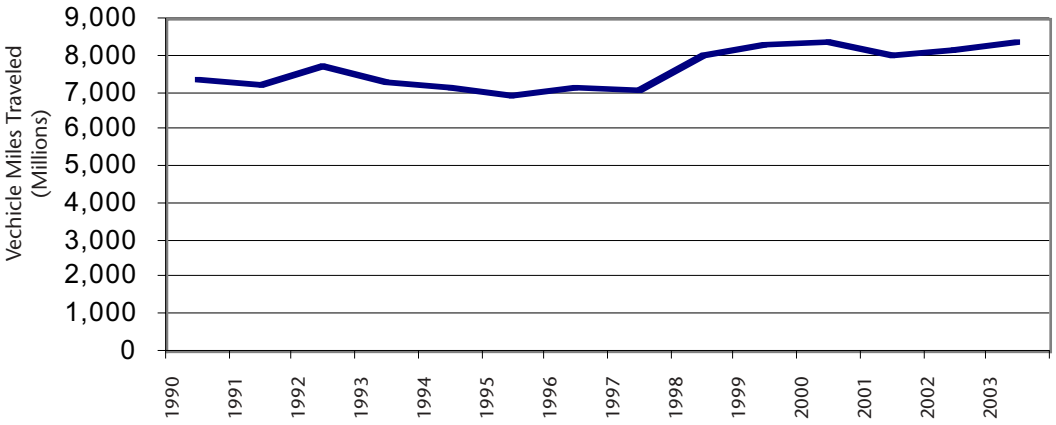
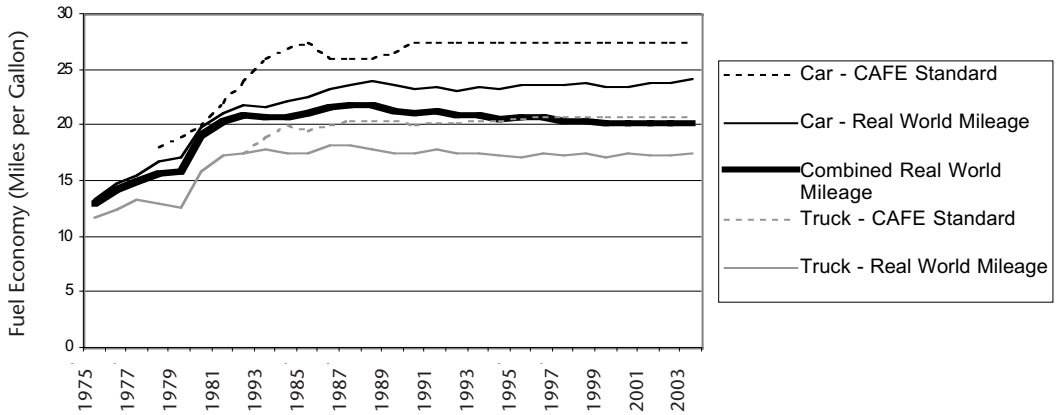


Figure 3. Average Fuel Economy for New Light-Duty Vehicle Fleet on the Decline[29]



sold in 1981. Indeed, the average real-world fuel economy of new cars and light trucks actually *declined* by 7 percent between 1988 and 2003.[28]

Amid growing public pressure to improve vehicle fuel economy, the U.S. Department of Transportation plans to increase CAFE standards for light trucks by a modest 1.5 MPG 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.

Growing Numbers of SUVs and Light Trucks

While the fuel economy of the average car and light truck has stagnated over the past two decades, the average fuel economy of the entire new-car fleet has declined—thanks to the dramatic shift 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 national light-duty vehicle market, vans 5 percent, and pickup trucks 13 percent. By model year 2004, however, SUVs accounted for 26 percent of light-duty vehicle sales, vans 7 percent, and pick-up trucks 15 percent. The light-duty market share of passenger cars and station wagons dropped over the same period from 80 percent to 52 percent.[30] (See Fig. 4.)

This shift in purchasing habits has caused the average fuel economy of the nation's new light-duty vehicle fleet to dip as low as 20.4 MPG in 2001—lower than at any time since 1980 and down by nearly 8 percent from the historical peak in 1987 and 1988.[31]

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 nationally will be light trucks.[32]

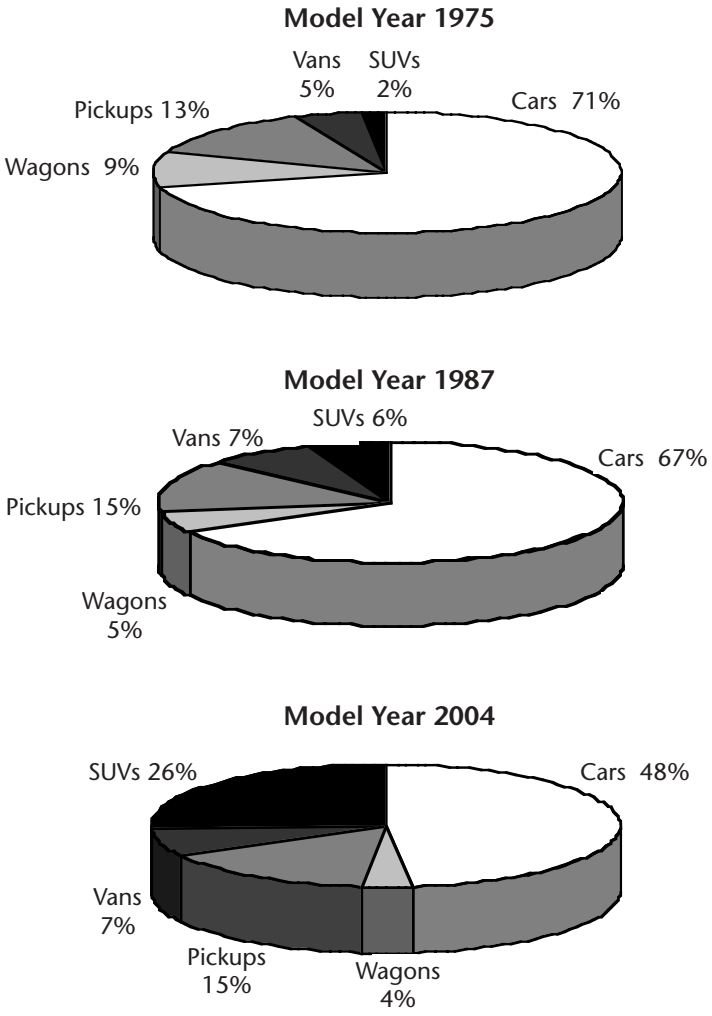
The combination of these three factors —more miles traveled, increasingly in trucks and SUVs, with stagnant fuel economy across the entire vehicle fleet—poses a great challenge to Rhode Island policymakers as they attempt to reduce global warming emissions from the transportation sector.

Vehicle Carbon Dioxide Emissions in Rhode Island: Past and Future

Based on Rhode Island-specific fuel consumption data compiled by the U.S. Energy Information Administration (EIA), cars and light-duty trucks released approximately 820 thousand metric tons carbon equivalent (thousand MTCE) of carbon dioxide into the atmosphere in 1990. By 2000, those emissions had increased by about 6 percent, to 870 thousand MTCE—meaning that cars and trucks were responsible for approximately one-quarter of Rhode Island's contribution to global warming in 2000.[33]

Any attempt to project Rhode Island's future global warming emissions depends greatly on the assumptions used. The "Assumptions and Methodology" section at the conclusion of this report describes these assumptions in detail. Simply put, the following projections (which are based largely on data and projections by state and federal government agencies and which we will term the "base case") assume continued growth in vehicle travel, slight improvement in vehicle fuel economy, and a continuation of the trend toward increased purchases of sport utility vehicles and other light trucks.[34]

Fig. 4 (a-c). National Purchasing of Light-Duty Vehicles Shifts from Cars to Trucks, Vans and SUVs

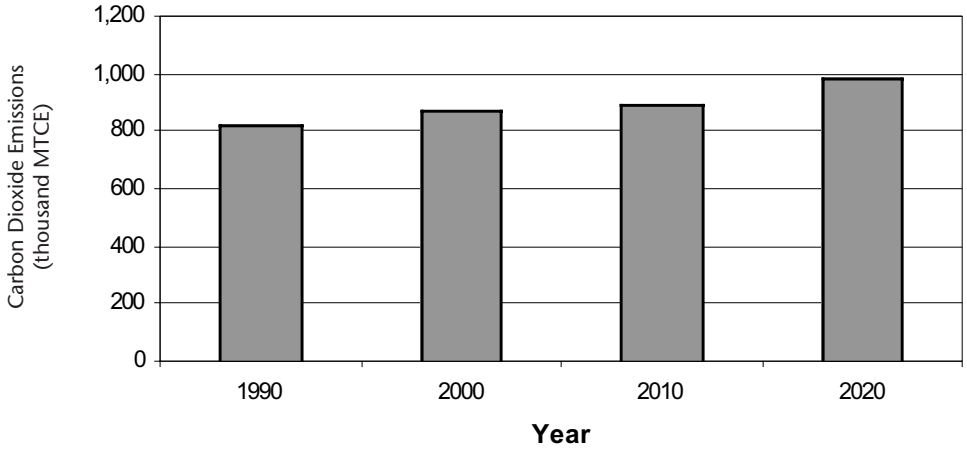


Based on these assumptions, carbon dioxide emissions from the Rhode Island light-duty vehicle fleet are projected to experience a 3 percent increase over 2000 levels by 2010, followed by a further 10 percent increase between 2010 and 2020. In other words, by 2020, carbon dioxide emissions from cars and light trucks will exceed 1990 levels by 21 percent in the absence of action to reduce emissions. (See Fig. 5.)

An increase of such magnitude would challenge Rhode Island's ability to meet its global warming emission reduction goals. Should these increases in global warming pollution from cars and light trucks occur, Rhode Island would need to achieve dramatic reductions in global warming pollution from other sectors of the state's economy over the next two decades in order to meet the goals of the plan.

However, this path toward increasing carbon dioxide emissions from cars and light trucks is not inevitable. Public policies that require or encourage the purchase of more fuel-efficient or advanced technology cars can make a significant dent in Rhode Island's future emissions of global warming gases. One of the most powerful such policy options is California's forthcoming limits on global warming pollution from vehicles.

Fig. 5. Actual and Projected Carbon Dioxide Emissions from Light-Duty Vehicles in Rhode Island, 1990-2020



Tools to Reduce Global Warming Emissions from Cars and Light Trucks

Rhode Island has many potential tools available to reduce emissions of global warming gases from the transportation sector. Among the most powerful of those tools are the global warming pollution standards for cars and trucks being developed by California.

The Clean Air Act gives most states two options for control of motor vehicle emissions: states may choose to comply with federal emission standards or to adopt the more protective standards implemented by the state of California, the only state empowered by the Clean Air Act to devise its own emission regulations.

Rhode Island—like six other states in the Northeast—has chosen to implement California's Clean Cars Standard for smog-forming and other toxic pollutants (which were updated in the late 1990s and are now known as the Low Emission Vehicle II, or LEV II, standards).

In addition, Rhode Island and other states will soon have the opportunity to adopt forthcoming standards to limit global warming pollution from cars and light trucks. The standards will likely bring about significant reductions in carbon dioxide emissions from cars and light trucks over the next decade.

As discussed below, Rhode Island's adoption of California's Clean Cars Standard provides a first step in reducing greenhouse gas emissions from vehicles. Adding global warming pollution standards would likely result in even more significant reductions in emissions of global warming gases from cars and trucks.

Rhode Island's options are not limited to these California-based policies. Other policies, such as requiring the use of low-rolling resistance tires on vehicles, can provide important assistance in Rhode Island's efforts to meet the state's climate change goals.

Clean Cars Standard

The California Clean Cars Standard seeks to reduce emissions of smog-forming and other hazardous pollutants. It achieves its goals by establishing fleet-wide limits on tailpipe emissions and by requiring the sale of advanced-technology vehicles such as hybrids that have even lower emissions. Eventually, the program calls for the sale of zero-emission vehicles (ZEVs). It is likely, however, that some of the technological changes encouraged by the Clean

Cars Standard will also reduce emissions of global warming gases as well.

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

Pure Zero-Emission Vehicles

"Pure" zero-emission vehicles (pure ZEVs) are those—like battery-electric and fuel-cell vehicles—that release no toxic or smog-forming pollutants from their tailpipes or fuel systems. They also have the potential to release far fewer global warming gases than today's vehicles.

The most recent revision to the Clean Cars Standard shifted the emphasis of the program from near-term deployment of battery-electric vehicles to the long-term development of hydrogen fuel-cell vehicles. As a result, automakers will not have to sell fuel-cell or other pure zero-emission vehicles in Rhode Island until at least model year 2012. Even then, the number of pure ZEVs required for sale in Rhode Island would be small, representing less than one percent of new car and light truck sales until model year 2016.[35]

In addition, the California Air Resources Board (CARB), which administers the program, is scheduled to review the status of fuel-cell technology prior to enforcing any pure ZEV requirements for the 2009 model year and beyond.[36]

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

Partial Zero-Emission Vehicle (PZEV) Credits

The majority of vehicles that automakers produce to comply with the Clean Cars Standard will be vehicles that receive "partial ZEV credit"—otherwise known as "PZEVs." PZEVs are like conventional gasoline vehicles in every way but one: they are engineered to produce dramatically lower emissions of smog-forming and other hazardous pollutants. Indeed, PZEVs are 90 percent cleaner than the average new vehicle sold today.[37]

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

Advanced Technology PZEVs (AT-PZEVs)

The greatest near-term global warming impact of the Clean Cars Standard will likely come from provisions to encourage the sale of advanced technology PZEVs, or AT-PZEVs, that can run on a cleaner alternative fuel, such as compressed natural gas, or that use advanced technologies, such as hybrid-electric drive. To encourage automakers to release additional new hybrid vehicles as early as possible, auto-makers are allowed to comply with up to 40 percent of their Clean Cars sales obligations in the early years of the program through the sale of AT-PZEVs.

Hybrid-electric vehicles are the most likely technology to be used to comply with AT-PZEV standards. Hybrids have proven to be very popular with consumers, especially in an era of higher and rapidly fluctuating gasoline prices. Sales of hybrid vehicles have increased steadily since their introduction to the domestic market in December 1999. About 85,000 hybrids were sold in the U.S. in 2004, an increase of 63 percent from the previous year.[38]

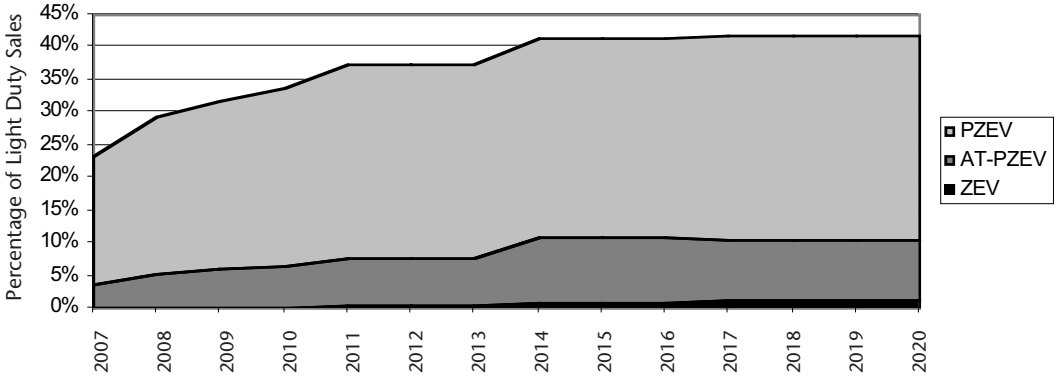
Thus far, there are four models of vehicles that have been certified to AT-PZEV emission standards: the hybrid Toyota Prius, Honda Civic, and Ford Escape, and

the natural gas-powered Honda Civic GX.[39] (Note that not all hybrid vehicles have low enough emissions to quality for AT-PZEV certification.) Unfortunately, although a healthy market for hybrids appears to exist, automakers have not yet supplied hybrids in large enough quantities to meet consumer demand. By the end of 2005, the demand crunch could ease as automakers plan to introduce at least six additional hybrid models—including hybrid versions of the Toyota Highlander SUV and Chevy Silverado pickup—that may qualify as AT-PZEVs if their emissions meet "super low-emission" (SULEV) standards.[40]

Should automakers choose to maximize their use of AT-PZEVs to comply with the Clean Cars Standard—and do so using vehicles similar to the Toyota Prius— hybrids could make up about 3.5 percent of car and light truck sales in 2007, increasing to 7 percent by 2012. (See Fig. 6.) This translates to sales of about 1,900 hybrids in Rhode Island in 2007, increasing to approximately 5,000 annually by 2014. Because the Clean Cars Standard offers a great deal of flexibility, however, automakers could choose to comply by manufacturing greater numbers of less-advanced hybrids or smaller numbers of pure ZEVs, among other options.

Also unclear is the degree of global warming pollution reductions that can be expected from vehicles complying with AT-PZEV standards. Hybrid-electric vehicles and alternative-fuel vehicles vary greatly in their emissions of global warming pollution. Some, like the Toyota Prius, offer great reductions in global warming pollution, while others, such as hybrid pickup trucks to be sold by General Motors and DaimlerChrysler, offer little reduction in global warming pollution versus conventional models. The Clean Cars Standard does provide additional credit to hybrid-electric vehicles that attain a greater share of their power from an electric motor (generally allowing them to achieve lower carbon dioxide emissions), but these credits are not directly tied to global warming pollution. (Note also that not all hybrids qualify for AT-PZEV credit because their emissions of other air pollutants are too high.) For the purposes of this analysis, we assume that hybrids manufactured to comply with AT-PZEV standards will release about 30 percent fewer global warming gases per mile than conventional vehicles.[42]

Fig. 6. Clean Cars Standard Percentage of Light-Duty Vehicle Sales, 2007 through 2020



Additional Uncertainty: Alternative Compliance Paths

In addition to the compliance flexibility that California designed into the Clean Cars Standard, Rhode Island offers manufacturers two early compliance options that introduce greater uncertainty about how automakers will choose to comply with the program's requirements, especially in the early years of implementation.

Both alternative compliance paths allow manufacturers to build credit for Clean Cars Standard-compliant vehicles placed in Rhode Island or California before the program begins in Rhode Island.[41] In one alternative compliance option, automakers can draw upon credits earned in California by selling advanced-technology vehicles. In model year 2008, credits that a manufacturer has not used up in California can be counted in Rhode Island, adjusted proportionally to Rhode Island's smaller vehicle market. The manufacturer can then use those credits to offset requirements of the Clean Cars Standard in Rhode Island.

Rhode Island's other alternative compliance option encourages manufacturers to sell cleaner cars in Rhode Island as soon as possible. Manufacturers may proportionally transfer their California credits to Rhode Island in model year 2005 and add to that credit bank by selling cars in Rhode Island. Each low- or zero-emission car sold in Rhode Island before the Clean Cars Standard officially begins in model year 2008 will be credited. In addition, for introducing cleaner vehicles in Rhode Island before being required to do so, an automaker earns a 25% bonus. For example, an AT-PZEV sold in model year 2005 is credited as if it were 1.25 AT-PZEVs sold in model year 2009. To ensure manufacturers are not over-credited for early implementation, any credits expended in California during 2005-2007 will be scaled to the Rhode Island market and subtracted from the credit bank.

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

Clean Cars Standard Impacts: Long Term

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

An example of the potential power of the program to hasten technological change is the development of hybrid vehicles. California's adoption of the original ZEV requirement sparked public and private-sector research efforts into the development of advanced batteries and electric-drive technologies. While the generation of full-function electric vehicles that resulted from that research—such as Honda's EV-Plus and General Motors' EV1—were not sold in large quantities, the research effort drove advances in electric vehicle technology that facilitated the birth of the popular hybrid-electric systems that now power hundreds of thousands of vehicles worldwide and have laid the groundwork for recent advances in fuel-cell vehicle technology.[43]

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

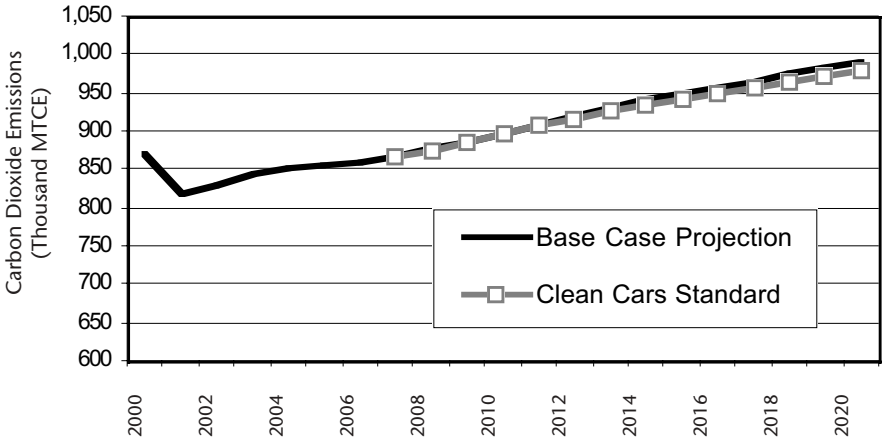
Clean Cars Standard Impacts: Short Term

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

We assume that automakers will take maximum advantage of the ability to meet Clean Cars Standard requirements with PZEVs and AT-PZEVs. We also assume that vehicles sold to meet AT-PZEV requirements are hybrid-electric vehicles with similar technological characteristics to the Toyota Prius. We assume that any vehicles sold to meet pure ZEV requirements are hydrogen fuel-cell vehicles whose fuel is generated from natural gas. We use conservative assumptions about the carbon dioxide emission reductions that could result from hybrid or fuel-cell vehicles. And, as noted above, we do not factor the availability of Rhode Island's alternative compliance paths into our analysis.

Using these assumptions, implementation

Fig. 7. Reductions in Carbon Dioxide Emissions Under Clean Cars Standard (Light-Duty Vehicles)



of the program in Rhode Island as scheduled beginning in the 2008 model year would reduce light-duty vehicle carbon dioxide emissions by about 1.2 percent versus base case projections by 2020—for a total reduction in emissions of about 12 thousand MTCE. (See Fig. 7.)

Rhode Island's adoption of the Clean Cars Standard will result in reduced global warming and toxic emissions from vehicles. Adopting California's global warming pollution standards for vehicles will provide even greater emission reductions.

Vehicle Global Warming Pollution Standards

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

The California legislation requires CARB to propose limits that "achieve the maximum feasible and cost effective reduction of greenhouse gas emissions from motor vehicles." Limits on vehicle travel, new gasoline or vehicle taxes, or limitations on ownership of SUVs or other light trucks cannot be imposed to attain the new standards.[44]

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

In developing the global warming pollution standards, the CARB staff reviewed several analyses of the types of technologies that could be used to achieve "maximum feasible and cost effective" reductions in global warming emissions from vehicles. Among the technological advances that can reduce global warming emissions are:

- **Smaller, more efficient engines,** made possible through the use of turbocharging, in which a turbine recaptures the 25 to 50 percent of an engine's energy that is lost through exhaust and redirects it into the engine; or through variable compression ratios that allow an engine to tailor compression rates to load conditions.[45]
- **Direct-injection engines** that allow greater control of the engine's use of fuel.[46]
- **Advanced transmissions** – such as five- and six-speed automatics and continuously variable transmissions—that allow a broader range of gear ratios.[47]
- **Integrated starter-generators** that allow greater power and enable the vehicle to take advantage of some features of hybridization (such as idle-off).[48]
- **Improved air conditioning systems**, which may include a more efficient compressor, leak less, and be filled with a refrigerant that contributes less to global warming.[49]
- **Weight reduction**, achieved through the use of lightweight materials such as high-strength low-alloy steel, aluminum, or magnesium alloys, or redesign to use less material in a car.[50]
- **More aerodynamic designs**, which can include a modified body shape or covers below the vehicle to reduce air drag.[51]
- **Cylinder deactivation** technology, which turns off half of the cylinders in the engine during some operating modes, such as steady-speed freeway driving.[52]
- **Improved lubricating oil** that reduces friction and cuts global warming emissions.[53]

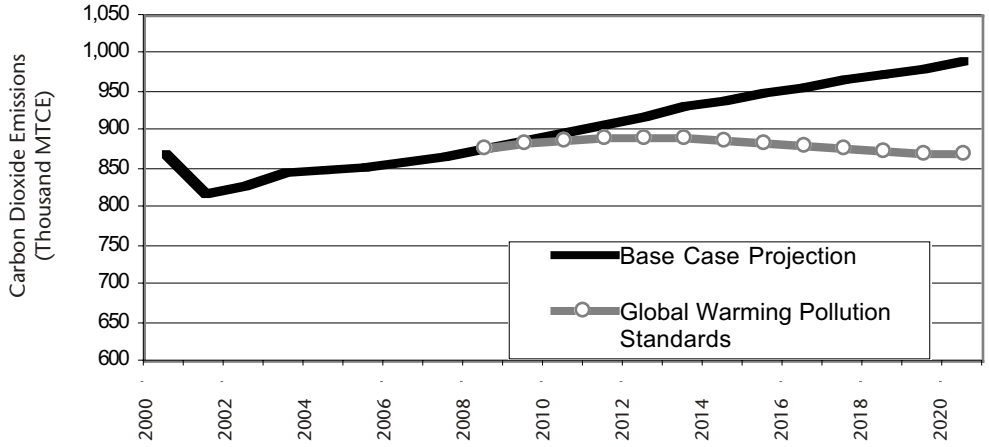
CARB's proposal estimates that near-term technologies could reduce average global warming emissions from cars by 25 percent and from light trucks by 18 percent. Over the medium term (2013 to 2016), cost-effective reductions of 34 percent for cars and 25 percent for light-trucks are feasible.[54]

The technological changes needed to achieve these reductions will likely result in modest increases in vehicle costs that would be more than recouped over time by consumers in the form of reduced fuel expenses. CARB projects that cars attaining the 34 percent reduction in global warming emissions required by 2016 would cost an average of $1,064 more for consumers, while light trucks achieving the required 25 percent reduction would cost about $1,029 more.[55]

However, the agency also estimates that the rules will significantly reduce operating costs for new vehicles—particularly for fuel. By subtracting operating cost savings from the projected additional monthly payment associated with purchasing vehicles that comply with the standard, CARB projects that, upon full phase-in, consumers will save $3 to $7 every month as a result of the standards. CARB also projects that the net impact of the standards to the state's economy will be positive, suggesting that ***Rhode Island could save money while at the same time reducing the state's overall emissions of global warming gases***.[56]

Assuming that the September 2004 version of the global warming pollution standards are adopted as proposed—and that Rhode Island would implement those standards beginning with the 2009 model year—the reductions in global warming pollution that would result would be significant. Compared to the base case projection, the pollution standards would reduce light-duty carbon dioxide emissions by 12 percent by 2020 – for a total reduction of 121 thousand MTCE. (See Fig. 8.) In addition, upstream carbon emissions likely would be reduced through lower demand for producing, refining and transporting fuel, but because many of these reductions would take place elsewhere, and not in Rhode Island, we do not count them in the benefits Rhode Island would achieve with this policy.

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



Low-Rolling Resistance Replacement Tires

Rhode Island can both enhance the savings achieved through global warming pollution standards for vehicles and begin reducing emissions sooner by requiring that replacement tires sold to consumers have low rolling resistance. Vehicles that comply with the ZEV standards or meet vehicle global warming emission limits, and vehicles that were sold before those programs were implemented can benefit from low-rolling resistance tires.

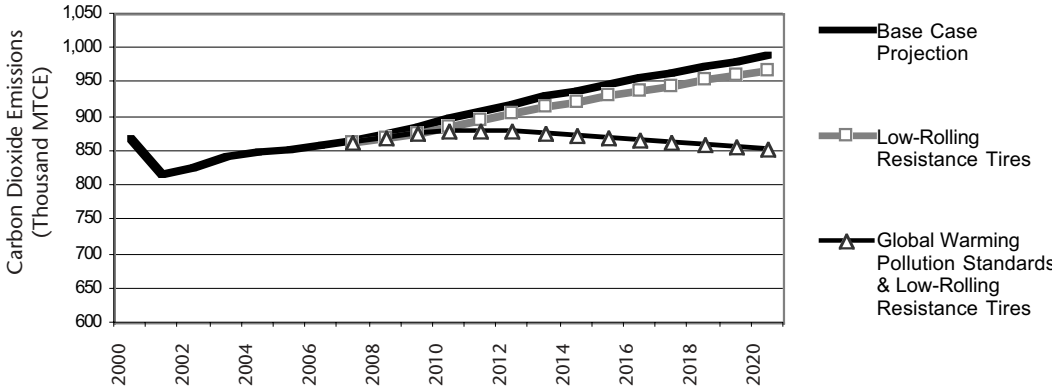
Automobile manufacturers typically include low-rolling resistance (LRR) tires on their new vehicles in order to meet federal corporate average fuel economy (CAFE) standards, and including LRR tires on new vehicles is one tool manufacturers may use to meet global warming pollution limits. However, LRR tires are generally not available to consumers as replacements when original tires have worn out. As a result, vehicles with replacement tires do not achieve the same fuel economy as vehicles with original tires.

The potential savings in fuel—and carbon dioxide pollution—are significant. A 2003 report conducted for the California Energy Commission found that LRR tires would improve the fuel economy of vehicles operating on replacement tires by about 3 percent, with the average driver replacing a vehicle's tires when the vehicle reaches four, seven and 11 years of age. The resulting fuel savings would pay off the additional $5 to $12 cost per set of tires in about one year, the report found, without compromising safety or tire longevity.[57]

Several potential approaches exist to encourage the sale and use of LRR tires—ranging from labeling campaigns (similar to the Energy Star program) to mandatory fuel efficiency standards for all light-duty tires sold in the state. California recently chose the latter approach, adopting legislation requiring that replacement tires sold to consumers beginning in July 2008 have the same average energy efficiency as the original tires provided by automakers.[58] The state will rate the energy efficiency of different tires based on testing information provided by manufacturers. The law does not require that each tire be labeled with its efficiency rating, but the information will be readily available to Rhode Island to develop similar requirements.

A standards program that required the sale of LRR tires beginning in 2007 in Rhode Island—assuming the same tire replacement schedule and per-vehicle emission reductions found in the California study—would ultimately reduce carbon

Fig. 9. Reductions in Carbon Dioxide Pollution Under Low-Rolling Resistance Replacement Tires (Light-Duty Vehicles)



dioxide emissions from the light-duty fleet by about 1.5 percent by 2010 and 2.2 percent by 2020, while also providing a net financial benefit to consumers through reduced gasoline costs.

Adopting both global warming pollution standards for vehicles and a LRR tires sales requirement would reduce vehicle global warming pollution in Rhode Island by 2.2 percent by 2010 and 14 percent by 2020. (See Fig. 9.)

Further, Rhode Island should encourage neighboring states to adopt similar requirements for the sale of replacement tires, creating a regional bloc of states with uniform requests for tire manufacturers and reducing the degree to which the impact of the program could be muted by consumers buying replacement tires in other states.

The Need for Additional Actions

Adopting global warming pollution standards in addition to the Clean Cars Standard can contribute significantly to Rhode Island's efforts to reduce global warming pollution from the transportation sector. Adopting the global warming pollution standards and a low-rolling resistance tire program would reduce global warming pollution from light-duty cars and trucks to slightly below 2000 levels in 2020. If no action is taken, pollution levels are expected to rise by 14 percent compared to 2000.

Thus, adoption of global warming pollution standards for vehicles and low-rolling resistance tire standards would not be enough to return transportation sector emissions to 10 percent below 1990 levels by 2020, the target Rhode Island agreed to under the Conference of New England Governors and Eastern Canadian Premiers Climate Change Action Plan. Should Rhode Island seek to achieve reductions similar to those called for in the plan for cars and light trucks, the state would need to achieve an additional 58 thousand MTCE of reductions by 2010 and 116 thousand MTCE of reductions by 2020.

A number of policy options, many of which were endorsed by the stakeholders, exist for closing this gap, including:

- Measures to reduce per-mile global warming pollution from vehicles, such as:
  - State or federal incentives for the purchase of vehicles with lower carbon emissions.
- Measures to reduce the rate of growth in vehicle travel, such as:
  - Improvements in the public transit system and other alternatives to automobile use.
  - Adoption of "pay-as-you-drive" insurance, in which insurance is charged by the mile, discouraging excessive driving.
  - Implementation of "smart growth" measures to reduce sprawling development and the accompanying need for vehicle travel.

Policy Findings

Attaining the reductions in global warming pollution required of Rhode Island under the regional Climate Change Action Plan will require significant actions to reduce emissions from light-duty vehicles.

To achieve this goal:

- The state should announce its commitment to adopt California's global warming pollution standards for cars and light trucks in 2005.
- Rhode Island should require the sale of low-rolling resistance tires to reduce emissions from all vehicles equipped with replacement tires.
- The state should take aggressive action to reduce transportation-sector global warming pollution, including actions that speed the deployment of environmentally preferable advanced-technology vehicles (such as hybrids), reduce the rate of growth in vehicle travel, and encourage improvements in the fuel economy of conventional vehicles.

Assumptions and Methodology

Projections of future global warming emissions from automobiles depend a great deal on the assumptions used. This section details the assumptions we made about future trends, explains the methodology we used to estimate the impact of various programs, and compares the results with data recently published by others.

Baseline Light-Duty Vehicle Carbon Dioxide Emissions

Carbon dioxide emissions from light-duty vehicles (cars and light trucks) in Rhode Island in 1990 and 2000 were based on state-specific motor gasoline usage data from U.S. Department of Energy, Energy Information Administration (EIA), *State Energy Data 2000 Consumption*, downloaded from www.eia.doe.gov/emeu/states/_use_multistate.html, 7 December 2004. Fuel consumption data for the transportation sector in BTU was converted to carbon dioxide emissions based on conversion factors from EIA, *Annual Energy Outlook 2003*, Appendix H and EIA, *Emissions of Greenhouse Gases in the United States 2001*, Appendix B. The proportion of transportation-sector gasoline emissions attributable to light-duty vehicles was estimated by dividing energy use by light-duty vehicles by total transportation-sector motor gasoline use as reported in EIA, *Annual Energy Outlook 2003*. Emissions from vehicles more than three years old were adjusted upward by 3 percent to account for the decrease in fuel efficiency that results when consumers replace the original low-rolling resistance tires provided by the manufacturer.

Vehicle-Miles Traveled

Historic vehicle-miles traveled data for Rhode Island were obtained from the Federal Highway Administration, Office of Highway Policy Information. Projected vehicle-miles traveled were estimated using an average annual growth rate of 1.17 percent. Twenty-year VMT growth data were provided by Gary Bowen, Transportation Management Center, Rhode Island Department of Transportation, personal communication, 9 December 2004. This growth rate is slightly higher than Rhode Island's average annual VMT growth rate from 1990 to 2003.

VMT Percentages by Vehicle Type

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

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

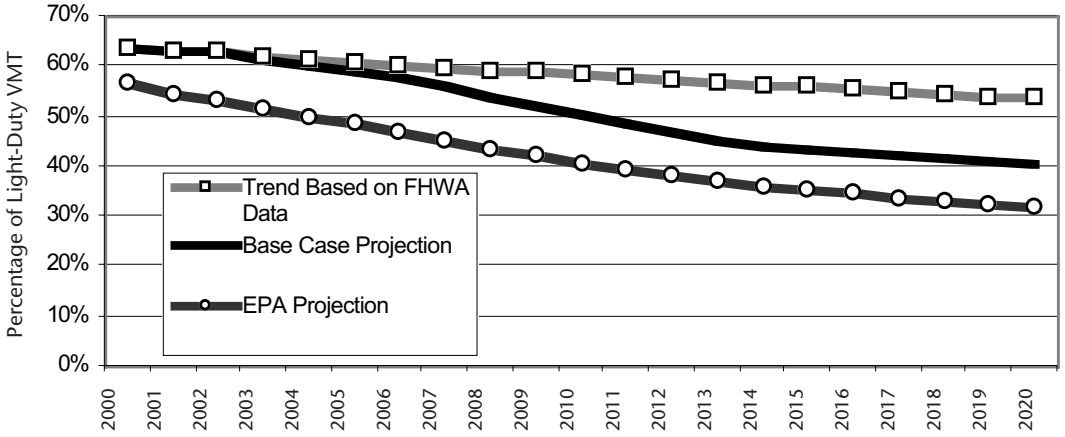
In order to estimate a trend that reflects both the more car-heavy current makeup of VMT and the long-term trend toward increasing travel in light trucks, we created two curves, one extrapolating the continued linear decline in the car portion of light-duty VMT based on trends in FHWA data from 1990 to 2002 and another using the EPA MOBILE6 estimates. We then assumed that the split in VMT would trend toward the EPA estimate over time, so that by 2020, cars are responsible for approximately 40 percent of light-duty VMT. (See Fig. 10.)

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

VMT Percentages by Vehicle Age

Vehicle-miles traveled by age of vehicle were determined based on VMT accumulation data presented in EPA, *Fleet Characterization Data for MOBILE6: Development*

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



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

Vehicle Carbon Dioxide Emissions

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

For conventional vehicles, a gallon of gasoline was assumed to produce 8,869 grams (19.6 pounds) of carbon dioxide. This figure is based on carbon coefficients and heat content data from U.S. Department of Energy, Energy Information Administration, *Emissions of Greenhouse Gases in the United States 2001*, Appendix B. Fuel economy estimates were based on EPA laboratory fuel economy values from EPA, *Light-Duty Automotive Technology and Fuel Economy Trends: 1975 Through 2004*, April 2004, multiplied by a degradation factor of 0.84 for years 2000 through 2020, based on the ratio of revised mpg to lab tested mpg as reported by EPA, *Light-Duty Automotive Technology and Fuel Economy Trends: 1975-2004*, April 2004. (The degradation factor represents the degree to which real-world fuel economy falls below that reported as a result of EPA testing.)

For hybrid-electric vehicles used to comply with AT-PZEV requirements, fuel economy was estimated to exceed that of conventional vehicles by 45 percent, per National Research Council, National Academy of Engineering, *The Hydrogen Economy: Opportunities, Costs, Barriers and R&D Needs*, the National Academies Press, 2004. This same document provided the assumption that hydrogen fuel-cell vehicles would achieve 140 percent greater fuel economy than conventional vehicles. This figure was then input into the Argonne National Laboratory's Greenhouse Gases Regulated Emissions and Energy Use in Transportation (GREET) model version 1.5a to produce an estimated grams CO_2/gasoline gallon equivalent for fuel-cell vehicles of 3,816 grams, which was then used to estimate emissions from hydrogen fuel-cell vehicles manufactured to comply with the Clean Cars Standard. (Fuel-cycle emissions from hydrogen fuel-cell vehicles were used in lieu of direct tailpipe emissions since fuel-cell vehicles emit no pollution from the tailpipe and it was assumed that the hydrogen fuel—and its associated emissions—would be created within Rhode Island.)

For the global warming gas emission standards, we assumed percentage reductions in per-mile vehicle emissions as described in California Environmental Protection Agency, Air Resources Board, *Staff Report: Initial Statement of Reasons for Proposed Rulemaking*, *Public Hearing to Consider Adoption of Regulations to Control Greenhouse Gas Emissions from Motor Vehicles*, 6 August 2004.

Clean Cars Standard Implementation

In calculating emission reductions resulting from the Clean Cars Standard, we assumed implementation of the program beginning in model year 2009 with the same requirements as the California program. Vehicles meeting the AT-PZEV standards were assumed to be "Type D" Hybrids (similar to the Toyota Prius), while vehicles meeting pure ZEV standards were assumed to be hydrogen fuel-cell vehicles whose fuel was produced from natural gas.

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

- Light-duty vehicle sales in Rhode Island for each category (cars and light trucks) were estimated based on year 2003 new vehicle registration figures from Alliance of Automobile Manufacturers, *Light Truck Country*, downloaded from autoalliance.org/archives/000141.html, 27 August 2004, with the light truck category divided into heavy

and light light-duty trucks using EPA fleet composition estimates as described above. These figures were then multiplied by the percentage of sales subject to the Clean Cars Standard for each year.

- This number was multiplied by 0.9 to account for the six-year time lag in calculating the sales base subject to the Clean Cars Standard. (For example, a manufacturer's requirements in the 2009 through 2011 model years are based on percentages of sales during model years 2003 through 2005.)
- Where necessary, these values were multiplied by the percentage of vehicles supplied by major manufacturers versus all manufacturers as calculated from Ward's Communications, *2003 Ward's Automotive Yearbook*, 233. (Non-major manufacturers may comply with the entire Clean Cars Standard requirement by supplying PZEVs.)
- This value was then multiplied by the percentage sales requirement to arrive at the number of Clean Cars Standard credits that would need to be accumulated in each model year.
- The credit requirement was divided by the number of credits received by each vehicle supplied as described in California Environmental Protection Agency, Air Resources Board, *Final Regulation Order: The 2003 Amendments to the California Zero Emission Vehicle Regulation*, 9 January 2004.
- The resulting number of vehicles was then divided by total light-duty vehicle sales to arrive at the percentage of sales required of each vehicle type.
- No pure ZEVs were assumed to be required for sale in Rhode Island until the 2012 model year. For the 2012 through 2017 model years, in which the pure ZEV requirement is based on a specific number of California sales, we divided the annual pure ZEV requirement in the California regulations by the number of new vehicles registered in California in 2001 per Ward's Communications, *2002 Ward's Automotive Yearbook*, 272. We assumed that the same percentage would apply to vehicle sales in Rhode Island.

It was assumed that manufacturers would comply with ZEV and AT-PZEV requirements through the sale of fuel-cell and hybrid passenger cars. While heavier light trucks are also covered by the Clean Cars Standard, manufacturers have the flexibility to use credits accumulated from the sale of cars to achieve the light-truck requirement. Percentages of various vehicle types assumed to be required under the Clean Cars Standard are depicted in Fig. 6, page 20 (assuming a roughly 60/40 percentage split between light-truck sales and car sales throughout the entire period).

Low-Rolling Resistance Tires

Savings from the use of low-rolling resistance replacement tires were estimated by reducing carbon dioxide emission factors by 3 percent from baseline assumptions and from the vehicle global warming emission standards scenario for vehicles reaching four, seven and 11 years of age beginning in 2005, per California Energy Commission, *California Fuel-Efficient Tire Report, Volume II*, January 2003. This estimate assumes that the tire stock will completely turn over; that is, that LRR tires will supplant non-LRR replacement tires in the marketplace through a state requirement. Other policies to encourage, but not mandate, LRR tires will likely produce reduced savings.

Fleet Emissions Projections

Based on the above data, five scenarios were created: a "Base Case" scenario based on projected trends in vehicle fuel economy, VMT and vehicle mix; a "Clean Cars

Standard" scenario based on the implementation scenario described above; a "Global Warming Pollution Standards" scenario based on the percentage emission reductions proposed by the CARB staff in August 2004; a "Low-Rolling Resistance Tire" scenario based on the percentage emission reductions found by the California Energy Commission; and a combined "Global Warming Pollution Standards and Low-Rolling Resistance Tire" scenario.

Projected emissions were based on the year-to-year increase (or decrease) in emissions derived from the estimation techniques described above. These year-to-year changes were then applied to the 2000 baseline emission level to create projections through 2020.

Other Assumptions

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

- **Rebound effects** – Research has shown that improved vehicle fuel 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.[59] To account for this effect, carbon dioxide reductions in each of the scenarios were discounted by 20 percent. This estimate is likely quite conservative: in its own analysis using California-specific income and transportation data, CARB estimated a rebound effect ranging from 7 percent to less than 1 percent.[60]
- **Mix shifting** – We assumed that none of the policies under study would result in changes in the class of vehicles purchased by Rhode Island residents or the relative amount that they are driven (rebound effect excluded). In addition, we assumed that the vehicle age distributions assumed by EPA remain constant under each of the policies. In other words, we assumed that any increase in vehicle prices brought about by the Clean Cars Standard or global warming emission standards would not dissuade consumers from purchasing new vehicles or encourage them to purchase light trucks when they would otherwise purchase cars (or vice versa). Mix shifting impacts such as these are quite complex and modeling them was beyond the scope of this report, but they do have the potential to make a significant impact on future carbon dioxide emissions.

Comparison With Other Published Estimates

Over the past year, several estimates of the benefits of the Clean Cars Standard and global warming gas emission standards have been made.

- **Clean Cars Standard** – The emission reductions from the Clean Cars Standard estimated here (12 thousand MTCE by 2020) are about 60 percent less than the reductions estimated in *Rhode Island Responds to Global Warming*. This is likely due to more conservative assumptions about the relative carbon dioxide emission reductions assumed to result from hybrid-electric and fuel-cell vehicles and a delay in the assumed date of implementation to model year 2008.
- **Global warming emission standards** – The emission reductions from the global warming emission standards estimated here (124 thousand MTCE by 2020) are approximately 30 percent greater than those estimated in *Rhode Island Responds to Global Warming*. The earlier report was produced prior to

California's proposal for implementation of the standards and included very conservative assumptions about the outcome of the program.

Notes

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

2. Ibid.

3. U.S. Environmental Protection Agency, *Global Warming-State Impacts: Rhode Island*, Office of Policy, Planning, and Evaluation, September 1998.

4. *Forestry, Land Use, and Climate Change: Strategies for Rhode Island*, presentation at workshop of Rhode Island Greenhouse Gas Process, 1 June 2004.

5. See note 3.

6. Ibid.

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

8. See note 3.

9. U.S. Environmental Protection Agency, *Global Warming-State Impacts: Rhode Island*, Office of Policy, Planning, and Evaluation, September 1998; New England Regional Assessment Group, U.S. Global Change Research Program, *Preparing for a Changing Climate: The Potential Consequences of Climate Variability and Change, Foundation Report*, September 2001.

10. Ibid.

11. Ibid.

12 Ibid.

13. Ibid.

14. Ibid.

15. Ibid.

16. Alison Bailie, et al, Tellus Institute, *Appendix D: Rhode Island Greenhouse Gas Baseline Scenario: Summary Figures and Tables*, prepared for the Rhode Island Greenhouse Gas Policy Stakeholder Group, 15 July 2002.

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

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

19. Based on data compiled for Rhode Island Public Interest Research Group Education Fund, Clean Water Fund, *Rhode Island Responds to Global Warming: Priority Policies for Reducing Rhode Island's Contribution to Global Warming*, Summer 2004.

20. See note 16.

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

22. Ibid.

23. Ibid.

24. VMT figures from Federal Highway Administration, Highway Statistics.

25. Ibid.

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

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

28. Ibid.

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

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

31. Ibid.

32. 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.

33. Based on comparison of light-duty vehicle emissions with overall Rhode Island global warming emissions from Tellus Institute, *Appendix D: Rhode Island Greenhouse Gas Baseline Scenario: Summary Figures and Tables*, prepared for the Rhode Island Greenhouse Gas Policy Stakeholder Group, 15 July 2002.

34. The projected emissions presented here are somewhat lower than the projections presented in Rhode Island Public Interest Research Group Education Fund, Clean Water Fund, *Rhode Island Responds to Global Warming: Priority Policies for Reducing Rhode Island's Contributions to Global Warming*, Summer 2004. See "Assumptions and Methodology" for a more detailed description the assumptions and estimation techniques used in this report.

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

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

37. California Air Resources Board, *Cleaner Gas Cars*, downloaded from www.driveclean.ca.gov/en/gv/driveclean/vtype_cleaner.asp, 1 July 2004.

38. 2004 sales information based on announcements from Honda, Toyota, and Ford, which were the only manufacturers to sell significant numbers of hybrids in 2004. Toyota, *Toyota Reaches Two Million in Sales For The First Time in 47-Year History* (press release), 4 January 2005; Honda, *American Honda Sets New All-Time Sales Record* (press release), 4 January 2005; and Steve Geimann, *Bloomberg*, "Ford Expands Lineup of Gas-Electric Hybrid Vehicles (Update3)," 9 January 2005.

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

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

41. State of Connecticut, Department of Environmental Protection, *Hearing Report: Regarding Regulations for the Abatement of Air Pollution: Proposed Adoption of Section 22a-174-35b and Proposed Amendment of Section 22-1-174-36(i) of the Regulations of Connecticut State Agencies*, 7 May 2004.

42. Based on estimated 45 percent improvement in fuel economy from hybrid-electric vehicles versus conventional vehicles in National Research Council, National Academy of Engineering, *The Hydrogen Economy: Opportunities, Costs, Barriers and R&D Needs*, The National Academies Press, 2004.

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

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

45. *Reducing Greenhouse Gas Emissions from Light-Duty Motor Vehicles*, Northeast States Center for a Clean Air Future, September 2004.

46. John DeCicco, Feng An, and 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.

47. Ibid.

48. Ibid.

49. California Environmental Protection Agency, Air Resources Board, *Staff Report: Initial Statement of Reasons for Proposed Rulemaking, Public Hearing to Consider Adoption of Regulations to Control Greenhouse Gas Emissions from Motor Vehicles*, 6 August 2004.

50. See note 46.

51. See note 45.

52. Ibid.

53. Ibid.

54. California Environmental Protection Agency, Air Resources Board, *Staff Report: Initial Statement of Reasons for Proposed Rulemaking, Public Hearing to Consider Adoption of Regulations to Control Greenhouse Gas Emissions from Motor Vehicles*, 6 August 2004. Earlier analysis by CARB suggested that even deeper cuts in vehicle emissions could be made more quickly. CARB's initial draft proposal for implementation of the standards called for cost-effective emission reductions of 22 percent from cars and 24 percent from light trucks in the near term. Over the medium term (2012 to 2014), cost-effective reductions of 32 percent for cars and 30 percent for light-trucks were deemed feasible. In addition, the standards were assumed to be phased in much more quickly than under CARB's final initial proposal. See California Environmental Protection Agency, Air Resources Board, *Draft Staff Proposal Regarding the Maximum Feasible and Cost-Effective Reduction of Greenhouse Gas Emissions from Motor Vehicles*, 14 June 2004.

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

56. California Environmental Protection Agency, Air Resources Board, *Staff Report: Initial Statement of Reasons for Proposed Rulemaking, Public Hearing to Consider Adoption of Regulations to Control Greenhouse Gas Emissions from Motor Vehicles*, 6 August 2004; California Environmental Protection Agency, Air Resources Board, *Addendum Presenting and Describing Revisions to: Initial Statement of Reasons for Proposed Rulemaking, Public Hearing to Consider Adoption of Regulations to Control Greenhouse Gas Emissions from Motor Vehicles*, 10 September 2004.

57. California Energy Commission, *California State Fuel-Efficient Tire Report: Volume 2*, January 2003.

58. Assembly Bill No. 844, signed into law 1 October 2003.

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