Cars and Global Warming

How the Clean Cars Program Curbs Global Warming Pollution in Oregon

Jeremiah Baumann
Elizabeth Ridlington

OSPIRG Foundation

October 2005

ACKNOWLEDGMENTS

The authors wish to acknowledge David Nordberg of the Oregon Department of Environmental Quality and Chris Hagerbaumer of the Oregon Environmental Council for providing peer review.

Sincere thanks to the Energy Foundation for providing financial support for this project.

The authors alone bear responsibility for any factual errors. The recommendations are those of the OSPIRG Foundation. The views expressed in this report are those of the authors and do not necessarily reflect the views of those who provided editorial or technical review.

OSPIRG Foundation is a nonprofit 501(c)(3) organization that offers an independent voice on behalf of the public interest in Oregon, at a time when public debate is too often dominated by powerful special interests pursuing their own agendas at the expense of the public good. We investigate problems, craft solutions, educate the public, train public interest leaders, and offer citizens meaningful opportunities for civic participation.

For additional copies of this report, send $10 (including shipping) to:

OSPIRG Foundation
1536 SE 11th Ave
Portland, OR 97214

For more information about OSPIRG, the OSPIRG Foundation, or OSPIRG student chapters, please contact our office at 503-231-4181 or visit the OSPIRG web site at www.ospirg.org.

Design: Kathleen Krushas, To the Point Publications

Table of Contents

Executive Summary

Oregon has options available now to significantly limit its contribution to global warming from cars and light trucks. This report examines the impacts of global warming on Oregon, the contribution of cars and light trucks to global warming, the projected growth in pollution from cars and light trucks, the global warming pollution reductions that can be achieved by adopting the Clean Cars program, and other steps needed to curb global warming pollution from cars and trucks.

Scientists agree that global warming poses a serious threat to Oregon's future. Scientists are now "very certain" that the region is warming. Precipitation is increasing, sea levels on parts of the Oregon Coast are rising, and snowpack in the Cascades is declining. Eventually, if no action is taken to reduce emissions of global warming pollution, these effects could add up to coastal flooding and erosion; reduced summer river flow for hydropower generation, salmon migration, and farm irrigation; and increased air pollution and heat-related deaths, among a host of other impacts on Oregon's environment, public health and economy.

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

The transportation sector is responsible for 38 percent of Oregon's releases of carbon dioxide, the leading global warming gas. Cars and light trucks—such as pickups, minivans and SUVs—are the most important sources of global warming pollution in the transportation sector.

Carbon dioxide pollution from cars and light trucks in Oregon is likely to increase to approximately 31 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 all put Oregon on a course toward dramatically increased emissions of carbon dioxide from transportation over the next two decades.

Oregon can achieve significant reductions in its carbon dioxide emissions by implementing the Clean Cars program:

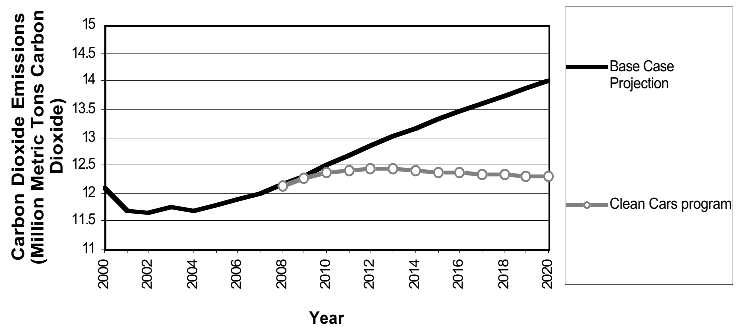
- Implementation of the global warming pollution standards in the Clean Cars program would produce significant reductions in vehicle global warming emissions as cars are equipped with currently-available technologies such as direct-injection engines, advanced transmissions, improved air conditioning systems, and other advanced technologies. **By implementing the program in 2005 (to take effect in model year 2009), Oregon will reduce carbon dioxide pollution from cars and light trucks by 12.3 percent below projected levels by 2020.**

- **The Zero-Emission Vehicle (ZEV) requirements in the Clean Cars program will result in sales of approximately 7,000 hybrids annually in Oregon, starting with model year 2009, increasing to 14,000 by model year 2016.** This requirement will pave the way for the widespread introduction of clean vehicles (including not just hybrids but eventually fuel-cell vehicles and other advanced technologies) that could result in the dramatic long-term reductions in global warming pollution necessary to truly curb global warming. In addition, the ZEV requirement will lead to light-duty carbon dioxide emissions reductions of about 1.4 percent below projected levels by 2020.

- Once the program is fully implemented in 2016, consumers are projected to save at least $3 to $7 every month as a result of the reduced operating costs associated with the standards – and more if gasoline prices remain high. **Drivers who purchase a new car or light truck in 2016 would collectively save at least $8.2 million annually. Once the loans for those vehicles are paid off, collective annual savings would be $40.3 million.** If gas prices remain as high as they currently are, savings will be even greater. They will also be greater for drivers who do not finance their cars.

- While implementing the Clean Cars program will contribute significantly to reducing global warming pollution, Oregon will need to adopt additional policies to reduce emissions from the transportation sector in order to stabilize and reduce total global warming pollution emissions in the long term. **Even with implementation of the Clean Cars program, carbon dioxide pollution from cars and light trucks could remain 1.7 percent higher in 2020 than in 2000, compared to 16 percent greater if no action is taken, (because of a large projected increase in vehicle travel.**

Figure ES-1. Estimated Oregon Carbon Dioxide Emissions from Cars and Light Trucks, 2000-2020



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

- Oregon should adopt the Clean Cars program in 2005 so that new emissions standards take effect in model year 2009.

- Oregon should adopt other programs that reduce global warming pollution from the transportation sector, such as clean car incentives that encourage individuals and fleets to purchase vehicles with lower global warming emissions, improved land-use planning to apply the best “smart growth” policies and reduce vehicle travel, continued transit improvements, and other measures.

Introduction

There is now scientific consensus that global warming is affecting our world. A December 2004 article in *Science* surveyed 928 randomly-selected scientific studies on the topic of global warming. Exactly zero questioned whether pollution from human activity is contributing to the warming of the planet.

The effects are not limited to faraway ice caps. In the summer of 2004, 46 Ph.D.-level scientists from universities in Oregon and Washington signed a consensus statement agreeing that "climate change is underway and that it is having global effects as well as impacts in the Pacific Northwest region." Their findings include temperature increases, rising sea levels on the central and northern Oregon coast, and a 50% decline in our snowpack, reducing streamflows that we depend on for irrigation, hydropower, and salmon migration.[1]

With Oregon's legacy of leadership and innovation when it comes to protecting the environment, it is important that the state lead the way toward curbing global warming pollution, particularly in the face of inaction by the Bush administration. Fortunately, clean energy options are available already to cut global warming pollution, and many of these options are not only good for the environment, but also for the economy.

Scientists from the Pacific Northwest have linked global warming to a measurable increase in sea levels along central and northern parts of the Oregon coast.

Governor Kulongoski has taken the first steps toward making Oregon a leader in the fight against global warming. His Advisory Group on Global Warming has recommended a broad set of actions to reduce global warming pollution. They include measures to increase the energy efficiency of appliances and buildings in Oregon, increase our use of clean renewable electricity sources, and cut global warming pollution from both the electricity and transportation sectors, two of the biggest sources.

Some of the Advisory Group's recommendations were enacted by the 2005 Oregon Legislature. Legislators passed (nearly unanimously) a bill to increase energy efficiency for eleven common appliances; the effect will be reductions in electricity consumption that are the equivalent, in terms of global warming pollution, of taking tens of thousands of cars off the roads. Legislators also passed a bill expanding the tax credit homeowners can take for installing solar electric systems.

Unfortunately, the global warming pollution cuts of these two measures are minor compared to the impact of one policy that the 2005 Oregon Legislature not only failed to pass, but tried to prohibit: cutting global warming pollution from cars and light trucks.

The technology already exists to reduce global warming pollution from passenger cars and light trucks, which are responsible for the greatest portion of the global warming pollution emitted by the transportation sector. And the technology is a win-win for the environment and the economy: cutting global warming pollution from cars and trucks will likely result in vehicles that go farther on a gallon of gas. That means a net benefit for consumers' and business' pocketbooks. Meanwhile, a host of newer technologies such as plug-in hybrids and fuel cell vehicles could play an important role in meeting the state's long-term global warming pollution reduction goals.

To take advantage of these technologies and reduce global warming pollution, Oregon must adopt the Clean Cars program. Rather than pass a bill directing Oregon's environmental agencies to adopt the program, the 2005 Legislature attached an amendment to the budget for the Department of Environmental Quality prohibiting the program. While the amendment would not have passed constitutional muster (Oregon's constitution prohibits the inclusion of unrelated matters in budget bills), the Governor did not wait for the courts. He used his line-item veto authority to strike the provision and, on the same day, put Oregon on the path to national leadership by instructing the Department of Environmental Quality to begin drafting rules to adopt the program.

The Clean Cars program will set strong global warming pollution limits for cars and light trucks and require that a percentage of vehicles sold be zero-emission or advanced-technology vehicles, such as hybrids. That means tens of thousands more advanced-technology cars and trucks for Oregonians – and increased consumer choice for Oregonians.

The Department of Environmental Quality will now propose rules to the Environmental Quality Commission, and the Commission must approve them by the end of the year in order to bring the Clean Cars program to Oregon by model year 2009. The auto industry has threatened to use "every arrow in [their] quiver" to stop these standards. But as this report shows, global warming is already affecting Oregon and the Clean Cars program offers a path toward substantial cuts in global warming pollution using technology available today. There is simply no excuse for delay.

Global Warming and Oregon

Human activities over the last century – particularly the burning of fossil fuels – have changed the composition of the atmosphere in ways that are already affecting Oregon's landscape and that threaten dramatic alteration of the global climate in the years to come. Those changes will have serious repercussions for Oregon.

Causes of Global Warming

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

Since 1750, the atmospheric concentration of carbon dioxide has increased by 31 percent. The current rate of increase in carbon dioxide concentrations is unprecedented in the last 20,000 years and the total concentration of carbon dioxide has not been higher in 420,000 years.[2] Concentrations of other global warming gases, such as methane and nitrous oxide, have increased as well.

As a result, average global temperatures increased during the 20th century by about 1° F. The 10 warmest years on record globally have all occurred since 1990; 19 of the 20 warmest have occurred since 1980. The planet is warming faster than at any time in the past 1,000 years.[3]

In the Pacific Northwest, temperatures have increased between 1° and 3° in the last century. Nearly every urban and rural temperature monitoring station in the Northwest has registered an increase in temperatures since 1920.[4]

If current trends in global warming pollution continue, temperatures could rise globally by an additional 2.5° F to 10.4° F by 2100.[5] In the Northwest, scientists expect an increase of between 0.2° and 0.9° F per decade, for an increase of 2.7° F by 2030 and 5.4° F by the 2050s. The Arctic Climate Impact Assessment forecasts an increase of between 7 and 13° F in the Arctic by the end of the century.

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, the effects of 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 in Oregon and around the world. Glaciers and tropical rainforests everywhere in the world have been shrinking and deteriorating throughout the 20th century. Areas of permafrost and seasonally frozen ground have also decreased. In the Northern Hemisphere, seasonally frozen areas decreased by 15 to 20 percent during 20th century.[6] At least half of the Arctic's summer sea ice could melt by century's end.[7]

Scientists in the Northwest agree on a range of specific impacts already being measured:

- The Northwest has seen a 10% increase in average precipitation since the beginning of the 20th century, with a 30-40% increase in eastern Washington and Northern Idaho, where precipitation affects flow levels in the Columbia and Snake watersheds.
- Rising sea levels on the central and northern Oregon coast (from Florence to Astoria) are submerging the land at a rate of 1.5-2 millimeters per year, according to data collected between 1930 and 1995. The total increase is approximately 4 inches.
- Total April 1 snowpack in the Cascades declined approximately 50% between 1950 and 1995. Most monitoring stations in the Pacific Northwest have shown a decline. As a result, the peak snowpack has shifted earlier in the year, by as much as 40 days. Accordingly, March river flows have increased, but June river flows have decreased.[8]

Future Impacts

The projected temperature increases in the Northwest described above are "highly likely" to result in an increase in the elevation of the upper tree line, longer growing seasons, increased length of the fire season, earlier breeding by animals and plants, longer and more intense allergy seasons, and possible changes in the areas where various vegetation types grow.[9] A longer growing season is a problem because it gives opportunities for pests and diseases to affect plants.

Future changes in precipitation are very difficult to predict because of limited scientific understanding about the interactions among atmosphere, land, and ocean systems in affecting climate. The snowpack will likely continue to decline, causing earlier peak stream flows, meaning increased flow in the winter and spring and decreased flow in the summer. The changes in timing will affect fish and wildlife, as well as commerce on the rivers. Increased winter flows, combined with increased storm intensity, could change our ability to manage flood damage. Reduced summer flows will reduce water available for hydropower generation and farm irrigation, particularly in Eastern Oregon where irrigation districts rely on melting snow during the summer. Reduced flows could also hurt salmon migration, affecting Oregon's fishing industry, and could reduce water quality because of higher water temperatures, increased salinity, and increased concentrations of pollution.[10]

According to Northwest scientists, sea level is "very certain" to continue to rise. The impact will vary, as the geology of the area is causing the land to rise (south of Florence, the land is rising fast enough to compensate for rising sea levels). Increasing sea levels will likely increase wave heights and cause increased erosion along the Oregon coast. The shoreline will likely move landward in some areas.[11] Possibly even more damaging could be increased frequency of storm surges, which could lead to saturated ground and more slope failure in coastal bluffs and hills.

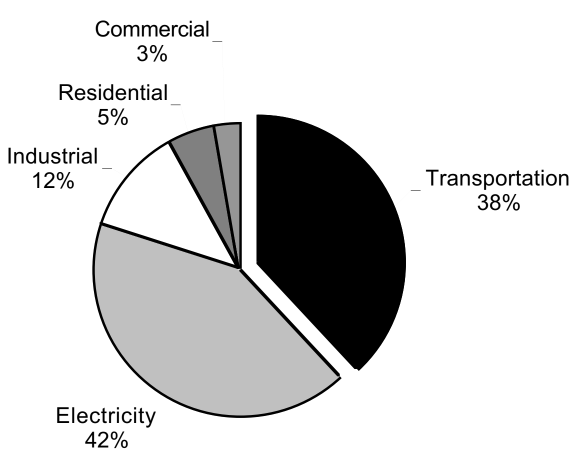
The likelihood and severity of these potential impacts is difficult to predict. But this much is certain: rapid changes in climate such as those predicted by the latest scientific research would have a dramatic, disruptive effect on Oregon's environment, economy and public health—unless immediate action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

Global Warming Pollution in Oregon

Carbon dioxide emitted from fossil fuel use is the leading cause of global warming. Oregon's total greenhouse gas emissions in 2000 were about 68 million metric tons of carbon dioxide equivalent. As of 2004, Oregon has been emitting global warming pollution at levels 15% higher than in 1990. If we continue ignoring these emissions, by 2025 Oregon's greenhouse gas emissions will be 61% higher than 1990 levels.[12]

The transportation sector is responsible for approximately 38% of Oregon's releases of carbon dioxide, second only to the electricity sector (42%). (See Figure 1.) Cars and light trucks—such as pickups, minivans and SUVs—are the most significant source of global warming pollution within the transportation sector.

Figure 1. Oregon Sources of Carbon Dioxide Emissions in 2000



A Note on Units

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

In this report, we use units of "carbon dioxide equivalent." Other documents communicate pollution in terms of "carbon equivalent"—the amount of carbon (in the form of carbon dioxide) that would need to be released to create a similar global warming effect. To translate the carbon dioxide equivalent to carbon equivalent, one can simply multiply by 0.2727.

The Transportation Challenge

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

Three trends in the transportation sector make the challenge of reducing global warming pollution in Oregon even greater.

Increasing Vehicle Miles Traveled (VMT)

Vehicle miles traveled (VMT) is the sum of distances traveled by all motor vehicles in a specified system of highway for a given period of time.

Other Important Global Warming Pollutants

This report focuses primarily on transportation-related pollution of carbon dioxide—the leading gas responsible for global warming and the global warming gas released in the largest quantities by cars and trucks. While carbon dioxide makes up 84% of Oregon's global warming emissions, cars and trucks also produce other global warming pollutants that must be considered in any emissions reduction strategy and which would be regulated by the Clean Cars program.

- **Methane** – Methane gas is the second-most important contributor to global warming, making up about 7% of Oregon's greenhouse gas emissions. Methane is a potent global warming pollutant – 30 times as potent as carbon dioxide – and may contribute significantly to global warming.

- **Nitrous Oxide** – Nitrous oxide is also produced in automobile exhaust, with mobile combustion sources estimated to contribute about 13 percent of U.S. nitrous oxide emissions in 2002[13] and about 18 percent of Oregon's emissions in 2000.[14] As with methane emissions, improved pollution control measures may reduce nitrous oxide emissions in the future. Nitrous oxide makes up 6% of Oregon's greenhouse gas emissions.

- **Hydrofluorocarbons (HFCs)** – HFCs are extremely potent global warming gases, yet tend to be released in only very small quantities. HFCs are often used a coolants in vehicle air conditioning systems and can escape from those systems into the environment. HFCs make up 1% of Oregon's greenhouse gas emissions.

- **Black carbon** – Black carbon, otherwise known as "soot," is a product of the burning of fossil fuels, including diesel fuel used in heavy-duty trucks and a small percentage of light-duty vehicles. Recent research has suggested that, because black carbon absorbs sunlight in the atmosphere and on snow and icepack, it may be a major contributor to global warming, perhaps second in importance only to carbon dioxide. Research is continuing on the degree to which black carbon pollution contributes to global warming.[15]

Oregon residents are traveling more miles than ever before. Between 1983 and 2003, the number of VMT annually on Oregon's roads increased from 20.7 million miles to 34.5 million miles —an increase of 66%.[16]

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.[17]

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.[18]

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

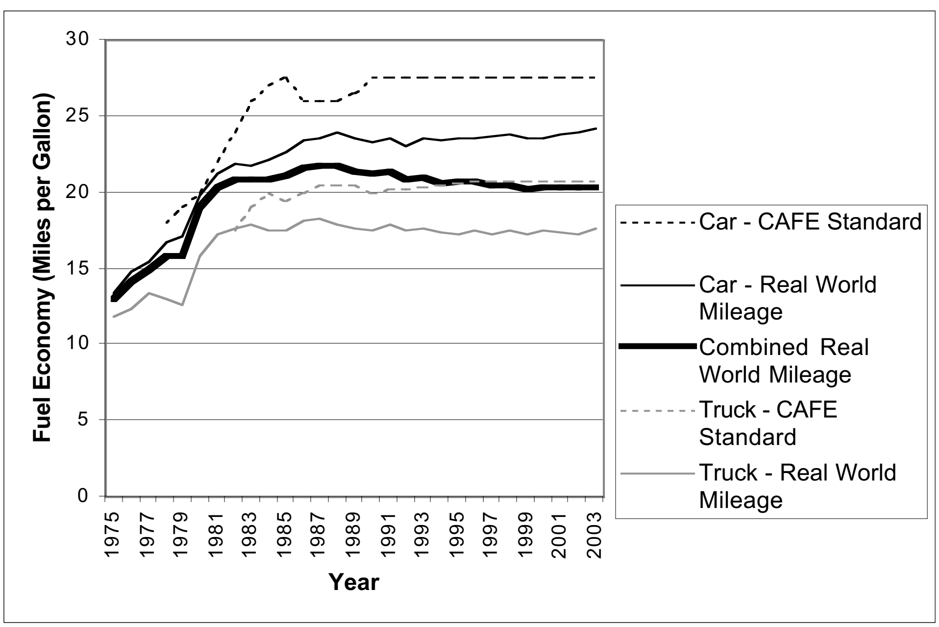
Until recently, the federal government had refused to increase CAFE standards for more than a decade. Changes in driving patterns—including higher speeds and increased urban driving—have led to a real-world decrease in fuel economy. An EPA analysis of fuel economy trends found that the average real-world fuel economy of light-duty vehicles sold in 2003 was lower than the average fuel economy of vehicles sold in 1981. Indeed, the average real-world fuel economy of new cars and light trucks actually *declined* by 7 percent between 1988 and 2003.[19] (See Figure 2.)

Amid growing public pressure to improve vehicle fuel economy, the U.S. Department of Transportation is increasing CAFE standards for light trucks by a modest 1.5 mpg between 2005 and 2007 and plans a further increase over the next several years. These actions do not go nearly far enough to take advantage of many technologies that could cost-effectively improve fuel economy, and the Department's proposed rule unfortunately contains loopholes allowing manufacturers to avoid increase fuel-efficiency standards by making slight increases in vehicle size.

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

Figure 2. Average Fuel Economy for New Light-Duty Vehicle Fleet on the Decline[20]



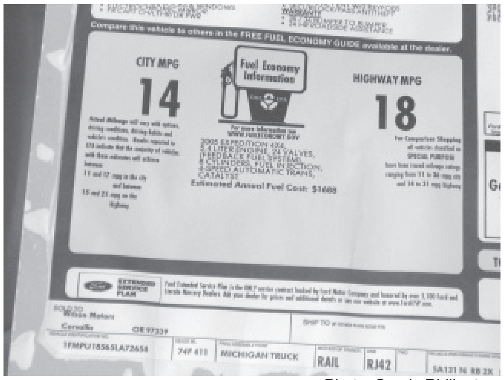


Photo: Sandy Ridlington

The low fuel economy of SUVs has contributed to a declining fleet-average fuel economy level.

declined—thanks to the dramatic shift toward sport utility vehicles (SUVs), vans and light trucks.

In 1975, when the first federal CAFE standards were enacted, SUVs made up 2 percent of the light-duty vehicle market, vans 5 percent, and pickup trucks 13 percent. By model year 2004, however, SUVs accounted for 26 percent of light-duty vehicle sales, vans 7 percent, and pick-up trucks 15 percent. The light-duty market share of passenger cars and station wagons dropped over the same period from 81 percent to 52 percent.[21] (See Figures 3a-3c.)

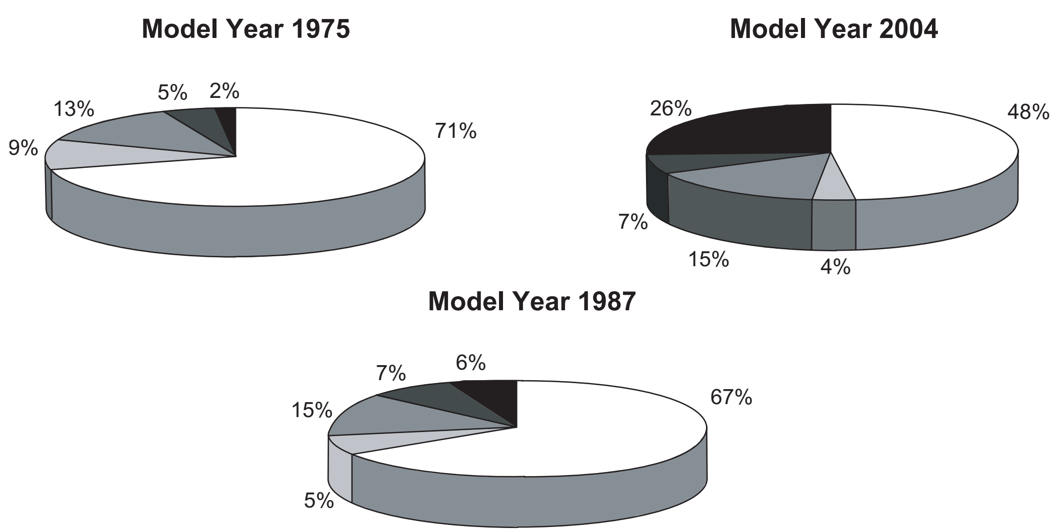
This shift toward larger vehicles has caused the average fuel economy of the entire new light-duty vehicle fleet to dip as low as 20.4 mpg in 2001—lower than at any time since 1980 and down by nearly 8 percent from the historical peak in 1987 and 1988.[22]

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 Oregon policymakers as they attempt to reduce global warming pollution from the transportation sector.

Vehicle Carbon Dioxide Pollution in Oregon: Past and Future

Based on Oregon-specific fuel consumption data compiled by the U.S. Energy Information Administration (EIA), cars and light-duty trucks released approximately 10.7 million metric tons of carbon dioxide ($MMTCO_2$) into the atmosphere in 1990. By 2000, those emis-

Figure 3 (a-c). Light-Duty Vehicle Mix Shifts from Cars to Trucks, Vans and SUVs



sions had increased by about 13 percent, to 12.1 $MMTCO_2$—meaning that cars and trucks were responsible for approximately 18 percent of Oregon's contribution to global warming in 2000.[23]

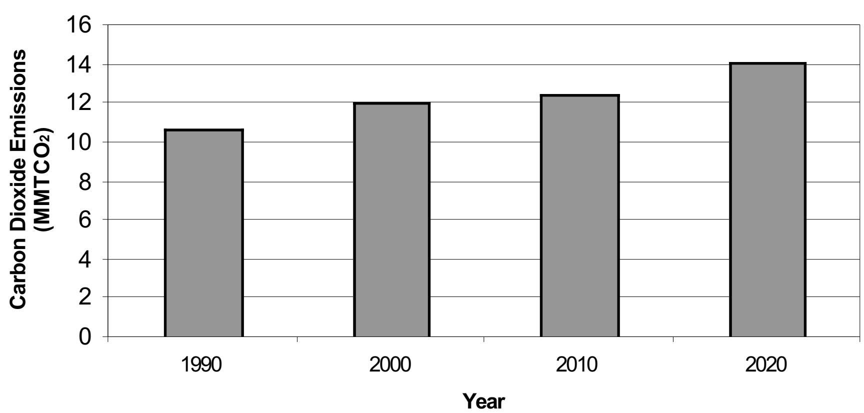
Any attempt to project Oregon's future global warming pollution depends greatly on the assumptions used. The "Assumptions and Methodology" section at the conclusion of this report describes these assumptions in detail. Simply put, the following projections (which are based largely on data and projections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

Based on these assumptions, carbon dioxide emissions from the Oregon light-duty vehicle fleet are projected to experience a 3 percent increase over 2000 levels by 2010, followed by a further 12 percent increase between 2010 and 2020. By 2020, carbon dioxide emissions from cars and light trucks will exceed 1990 levels by 31 percent in the absence of action to reduce emissions. (See Figure 4.)

An increase of such magnitude would severely challenge Oregon's ability to stabilize and eventually reduce global warming pollution from the transportation sector and for the state as a whole. Should these increases in emissions from cars and light trucks occur, Oregon would need to achieve dramatic reductions in global warming pollution from other sectors of the state's economy in order to achieve long-term reductions of 75 to 85 percent below 1990 levels, the level of reduction estimated by scientists as necessary to stabilize the climate and limit dangerous effects of global warming.[24] Governor Kulongoski has adopted a goal of reducing global warming pollution 75 percent below 1990 levels by 2050.

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

Figure 4. Actual and Projected Carbon Dioxide Emissions from Light-Duty Vehicles in Oregon, 1990-2020



Tools to Reduce Global Warming Pollution from Cars and Light Trucks

Oregon has many potential tools available to reduce emissions of global warming pollution from the transportation sector. Among the most powerful of those tools are the global warming pollution standards for cars and trucks contained in the Clean Cars program.

The Clean Air Act gives states two options for controlling motor vehicle pollution. States may choose to comply with federal emission standards or adopt the more protective standards implemented by the state of California, the only state empowered by the Clean Air Act to develop its own emission regulations for cars and trucks. The Clean Cars program is a package of air pollution regulations developed in California (and known there as the "Low Emissions Vehicle II" or "LEV II" program) to control air pollution from cars and light trucks.

For more than a decade, the Clean Cars program has limited smog-forming chemicals and toxic air pollution to more protective levels than federal standards. The program also includes a technology-driving policy called the Zero-Emission Vehicle, or ZEV, requirements. By putting more advanced-technology cars, such as hybrids, on the roads, the ZEV program will lower emissions of global warming gases, as well as smog-forming and toxic air pollutants.

In 2002, the California Legislature passed a law requiring the California Air Resources Board (CARB) to incorporate into the Clean Cars program standards limiting global warming emissions from cars and light trucks. CARB issued final standards in 2004. The standards will bring about significant reductions in carbon dioxide and other greenhouse gas emissions from cars and light trucks over the next decade.

Adopting the Clean Cars program, with both the global warming pollution standards and the ZEV requirements, is an important step in Oregon's efforts to reduce the state's global warming emissions.

Zero-Emission Vehicle Requirements

One part of the Clean Cars program—known officially as the Low Emission Vehicle II program—reduces emissions of smog-forming and other hazardous pollutants. These include toxic pollutants, such as benzene, that are in Oregon's air at dangerous levels. The LEV II program establishes fleet-wide limits on tailpipe emissions and also requires the sale of advanced-technology vehicles, such as hybrids, that have even lower emissions. These advanced-technology vehicle requirements, eventually call for the sale of zero-emission vehicles (ZEVs), and are therefore known as the ZEV requirements. The technological changes encouraged by the ZEV requirements will reduce emissions of global warming pollutants in addition to the other pollutants at which the requirement is aimed.

By adopting the program, Oregon can lay the groundwork to have increasing percentages of advanced-technology vehicles on the road over the next decade and more. The ZEV requirements have 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. (Note, however, that fuel-cell vehicles have zero emissions only if the hydrogen is generated from renewable sources.)

The ZEV requirements were recently modified to shift 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 Oregon until at least model year 2012. Even then, the number of pure ZEVs required for sale in Oregon would be small, representing less than one percent of new car and light truck sales until model year 2016.[25]

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.[26]

The ZEV requirements, therefore, currently require the sale of very few actual zero-emission vehicles over the next decade. But they do 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 ZEV requirements will be vehicles that receive "partial ZEV credit"—otherwise known as "PZEVs." PZEVs are conventional gasoline vehicles in every way but one: they are engineered to produce dramatically lower emissions of air toxics and smog-forming pollutants.

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

Advanced Technology PZEVs (AT-PZEVs)

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

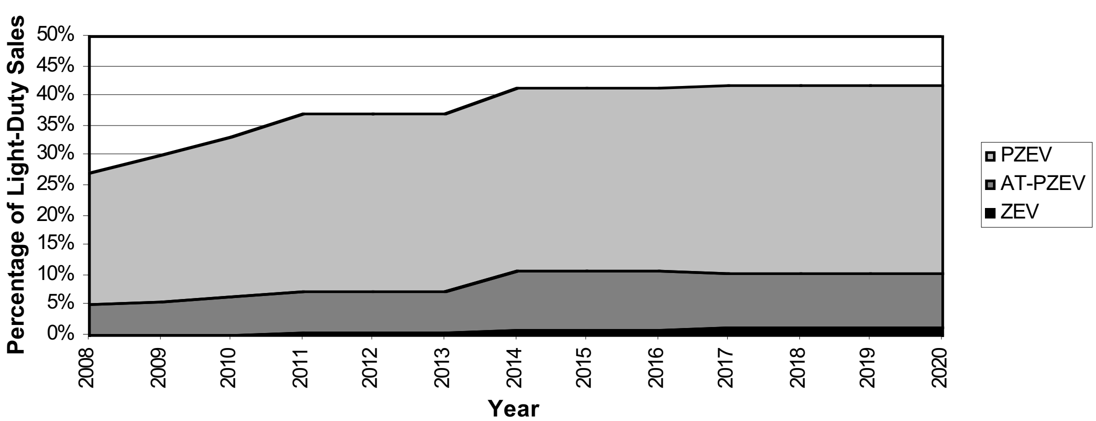
Hybrid-electric vehicles are the most likely technology to be used to comply with AT-PZEV standards. Hybrids have proven to be very popular with consumers, especially in an era of higher and rapidly fluctuating gasoline prices. Sales of hybrid vehicles have increased steadily since their introduction to the domestic market in December 1999. About 85,000 hybrids were sold in the U.S. in 2004, almost double the sales of the previous year.[27]

Thus far, four models of vehicles have been certified to AT-PZEV emission standards: the Toyota Prius, the Honda Civic hybrid, the Ford Escape hybrid, and the natural gas-powered Honda Civic GX..[28] (Several other hybrid vehicles, such as the Honda Accord, are on the market but either their emissions are too high to meet AT-PZEV standards or the automaker does not want to offer the extended warranty required with PZEVs. These vehicles nonetheless can achieve measurable reductions in global warming emissions.) Unfortunately, although a healthy market for hybrids appears to exist, automakers have not yet supplied hybrids in large enough quantities to meet consumer demand. By the end of 2005, the demand crunch could ease slightly if automakers introduce six additional hybrid models as planned—including hybrid versions of the Nissan Altima and Toyota Highlander—that could qualify for AT-PZEV credit.[29]

Should automakers choose to maximize their use of AT-PZEVs to comply with the ZEV requirements—and do so using vehicles similar to the Toyota Prius—hybrids could make up about 5.1 percent of Oregon car and light truck sales in 2008, increasing to 7 percent by 2012. (See Figure 5.) This translates to sales of about 7,000 hybrids in Oregon in 2008, increasing to approximately 14,000 annually by 2016. Because the ZEV requirements offer a great deal of flexibility, however, automakers could choose to comply by manufacturing greater numbers of less-advanced hybrids or smaller numbers of pure ZEVs, among other options.

Also unclear is the degree of global warming gas reductions that can be expected from vehicles complying with AT-PZEV standards. Hybrid-electric vehicles and alternative-fuel vehicles vary greatly in their emissions of global warming pollution. Some, like the Toyota Prius, offer great reductions in global warming emissions. Others, such as hybrid pickup trucks to be sold by General Motors and DaimlerChrysler, continue to have significant global warming pollution despite their improved emissions compared to conventional models. The ZEV requirements provide additional credit to hybrid-electric vehicles that attain a greater share of their power from an electric motor (generally allowing them to achieve lower carbon dioxide emissions), but these credits are not directly tied to global warming pollution. For the purposes of this analysis, we assume that hybrids manufactured to comply with AT-PZEV standards will release about 30 percent fewer global warming gases per mile than conventional vehicles.[30]

Figure 5. ZEV Percentage of Light-Duty Vehicle Sales, 2008 through 2020



The ZEV Requirements: Long-Term Impacts

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

An example of the potential power of the program to hasten technological change is the development of hybrid vehicles. California's adoption of the original ZEV requirement sparked public- and private-sector research efforts into the development of advanced batteries and electric-drive technologies. While the generation of full-function electric vehicles that resulted from that research—such as Honda's EV-Plus and General Motors's EV1—were not sold in large quantities, the research effort drove advances in electric vehicle technology that facilitated the birth of the popular hybrid-electric systems that now power hundreds of thousands of vehicles worldwide and have laid the groundwork for recent advances in fuel-cell vehicle technology.[31]

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

The ZEV Requirements: Short-Term Impacts

The short-term impact of the ZEV requirements on carbon dioxide emissions in Oregon 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 the ZEV requirements with PZEVs and AT-PZEVs. We also assume that vehicles sold to meet AT-PZEV requirements are hybrid-electric vehicles with similar technological characteristics to the Toyota Prius. We assume that any vehicles sold to meet pure ZEV requirements are hydrogen fuel-cell vehicles whose fuel is generated from natural gas. And we use conservative assumptions about the carbon dioxide emission reductions that could result from hybrid or fuel-cell vehicles.

Using these assumptions, implementation of the program in Oregon as scheduled beginning in the 2009 model year would reduce light-duty vehicle carbon dioxide emissions by about 1.4 percent versus base case projections by 2020—for a total reduction in emissions of about 0.2 $MMTCO_2$. (See Figure 6.)

Oregon's adoption of the Clean Cars standards will result in reduced global warming and toxic pollution from vehicles as the ZEV requirements take effect. Implementing vehicle global warming pollution standards will provide even greater emission reductions.

Vehicle Global Warming Pollution Standards

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

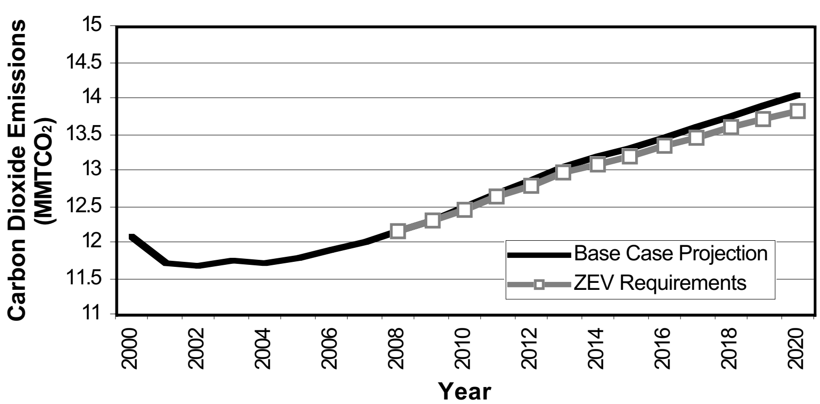
The legislation required the California Air Resources Board (CARB) to propose limits that "achieve the maximum feasible and cost effective reduction of greenhouse gas emissions from motor vehicles." Limits on vehicle travel, new gasoline or vehicle taxes, or limitations on ownership of SUVs or other light trucks cannot be imposed to attain the new standards.[32]

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

In developing the global warming pollution standards, the CARB staff reviewed several analyses of the types of technologies that could be used to achieve "maximum feasible and cost effective" reductions in global warming pollution from vehicles. CARB's proposal estimates that near-term technologies could reduce average global warming pollution from cars and the lightest light trucks by 25 percent and from heavier light trucks by 18 percent. Over the medium term (2013 to 2016), cost-effective reductions of 34 percent for cars and smaller light trucks and 25 percent for heavier light trucks are feasible.[33]

The technological changes needed to achieve these reductions (such as five and six-speed automatic transmissions and improved electrical systems) will likely result in modest increases in vehicle costs that would be more than recouped over time by consumers in the form of reduced fuel expenses. CARB projects that cars and the lightest light trucks attaining the 34 percent reduction in global warming pollution required by 2016 would cost an average of $1,064 more for consumers, while heavier light trucks achieving

Figure 6. Projected Reductions in Carbon Dioxide Emissions Under ZEV Requirements (Light-Duty Vehicles)



the required 25 percent reduction would cost about $1,029 more.[34]

However, the agency also estimates that the rules will significantly reduce operating costs for new vehicles. Though consumers will face higher monthly loan payments when purchasing vehicles that comply with the standards, those increased costs will be more than offset by lower operating expenses. For example, a consumer who buys a new car in 2016 will pay $20 more per month on the car loan but will save $23 per month in operating expenses, for a total savings of $3 per month. After the loan is paid off, the consumer will save the full $23 per month.

Assuming that the same number of cars and light trucks are sold annually in 2016 as are sold now and that every vehicle is financed with a loan, drivers who purchase a new car or light truck in 2016 collectively would save $8.2 million. Once the loans for those vehicles are paid off, collective annual savings would be $40.3 million. Savings of this level would accrue for vehicles purchased in other years, also.

Drivers who purchase a light truck or who pay for the vehicle in cash will experience greater savings.[35] (See Table 1.) These savings assume gasoline costs of $1.74 per gallon.[36] Higher prices will increase the savings to consumers. CARB also projects that the net impact of the standards to the state's economy will be positive, suggesting that Oregon could save money while at the same time reducing the state's overall emissions of global warming pollution.[37]

Table 1. Net Savings for Consumer Under Global Warming Pollution Standards in 2016[38]

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

Assuming that the September 2004 version of the global warming pollution standards is adopted as proposed, when Oregon implements those standards beginning with the 2009 model year the resulting reductions in global warming pollution would be significant. Compared to the base case projection, the emission standards would reduce light-duty carbon dioxide emissions by 12.3 percent by 2020—for a total reduction of 1.7 $MMTCO_2$. (See Figure 7.)

The Need for Additional Actions

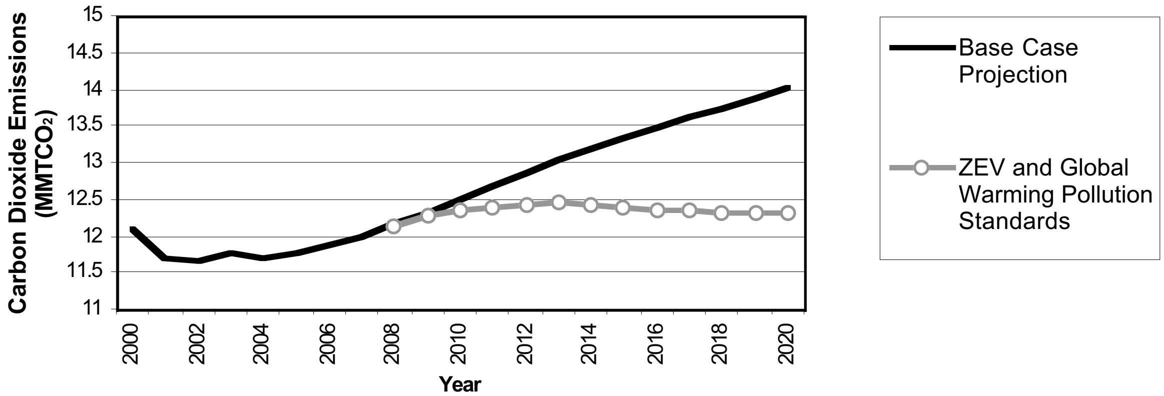
Implementing the Clean Cars program will contribute significantly to efforts to reduce global warming pollution from Oregon's transportation sector. With both components in effect, emissions from light-duty cars and trucks would be 1.7 percent greater in 2020 than they were in 2000, compared to 16 percent greater if no action is taken.

Though it yields significant progress and is a major step forward, implementing the Clean Cars program will not be enough to reduce vehicle emissions below 1990 levels. Oregon will need to do far more to reduce global warming pollution from cars and light trucks and must pay special attention to reducing the growth in vehicle-miles traveled.

A number of policy options exist for Oregon to further reduce emissions from cars and light trucks, including:

- Cents-per-mile insurance, which can be offered by private insurers and allows drivers to purchase vehicle insurance by the mile. Such a program makes drivers more aware of the full costs of each mile driven and can re-

Figure 7. Reductions in Carbon Dioxide Emissions Under Clean Cars Program (Including ZEV Requirements and Global Warming Pollution Standards, Light-Duty Vehicles)**Figure 7. Reductions in Carbon Dioxide Emissions Under Clean Cars Program (Including ZEV Requirements and Global Warming Pollution Standards, Light-Duty Vehicles)**



duce excessive driving. It can also provide a benefit to senior citizens and others who drive less than average. Oregon has a tax credit available for companies who offer pay-as-you-drive insurance.

- Improved transit service. Better bus and rail service within and between cities would reduce the amount citizens need to drive. Carpools and vanpools can help serve areas not accessible to transit.
- Incentives for individuals and fleets to purchase vehicles with lower carbon emissions. Oregon already has a tax credit available to purchasers of alternative-fuel vehicles, which includes hybrids. One possible improvement would be to make the credit available only to cars that exceed the Clean Cars program's standards and make the credit proportional to reductions in global warming pollution. Another approach would be to create a program offering a rebate to car buyers who purchase vehicles that emit less global warming pollution and putting a fee on purchasers of less efficient vehicles. The program could thus be revenue-neutral for the state. Connecticut and several other New England states are considering such a program.[39]

The federal government also could assist Oregon's efforts to reduce global warming pollution by increasing the federal corporate average fuel economy (CAFE) standard.

Photo: Sandy Ridlington

Increasing numbers of SUVs and pickup trucks have added to Washington's global warming pollution.

Policy Findings

Attaining reductions in carbon dioxide emissions will require significant actions to reduce emissions from light-duty vehicles.

To achieve this goal:

- Oregon should adopt the Clean Cars program so that it will take effect in 2008.
- The state should take aggressive action to further reduce transportation-sector global warming pollution, including actions that speed the deployment of environmentally preferable vehicles (such as hybrids with low greenhouse gas emissions), reduce the rate of growth in vehicle travel, and encourage improvements in the fuel efficiency of conventional vehicles.

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

Baseline Light-Duty Vehicle Carbon Dioxide Emissions

Carbon dioxide emissions from light-duty vehicles (cars and light trucks) in Oregon 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 2001: Consumption* (downloaded from www.eia.doe.gov/emeu/states/sep_use/total/pdf/use_all.pdf, 7 July 2005). Fuel consumption data for the transportation sector in BTU was converted to carbon dioxide emissions based on conversion factors from EIA, *Annual Energy Outlook 2003*, Appendix H and EIA, *Emissions of Greenhouse Gases in the United States 2001*, Appendix B. The proportion of transportation-sector gasoline emissions attributable to light-duty vehicles was estimated by dividing energy use by light-duty vehicles by total transportation-sector motor gasoline use as reported in EIA, *Annual Energy Outlook 2003*.

Vehicle-Miles Traveled

Historic vehicle-miles traveled data for Oregon were obtained from Federal Highway Administration, U.S. Department of Transportation, *Highway Statistics, Table VM-2, Functional System Travel*, for 1990-2003. Projected vehicle-miles traveled were obtained from Oregon's Department of Transportation.

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. (Oregon-specific data on VMT splits are unavailable but the state has a higher ratio of registered trucks to cars than the national average, according to Federal Highway Administration, *Highway Statistics 2002*, October 2003, Table MV-1. This may make our analysis of the programs' benefits slightly higher than will likely occur because per-mile emission reductions for cars are greater than for trucks and total emission reductions are overcounted in Oregon 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 Figure 8.)

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

VMT Percentages by Vehicle Age

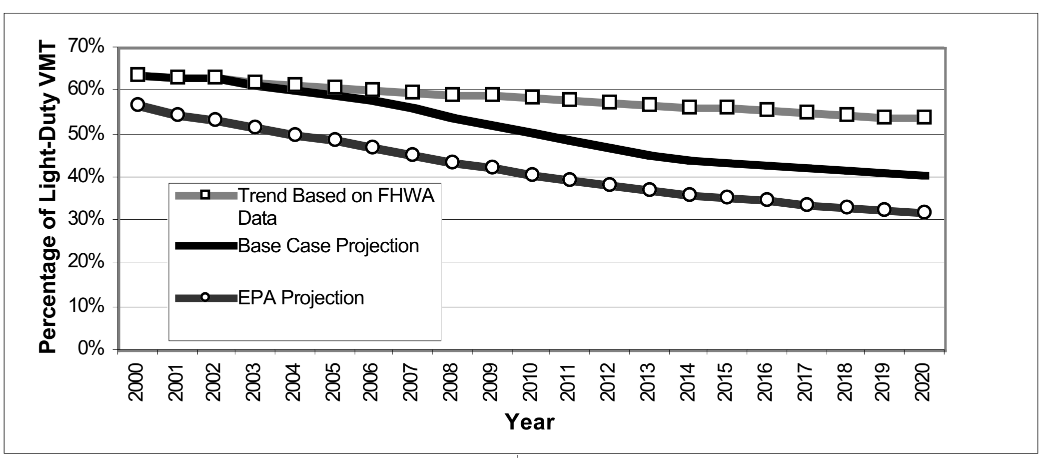
Vehicle-miles traveled by age of vehicle were determined based on VMT accumulation data presented in EPA, *Fleet Characterization Data for MOBILE6: Development and Use of Age Distributions, Average Annual Mileage Accumulation Rates, and Projected Vehicle Counts for Use in MOBILE6*, September 2001.

Vehicle Carbon Dioxide Emissions

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

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

Figure 8. Percentage of Light-Duty Vehicle-Miles Traveled in Cars



Light-Duty Automotive Technology and Fuel Economy Trends: 1975-2004, April 2004. (The degradation factor represents the degree to which real-world fuel economy falls below that reported as a result of EPA testing.)

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

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

ZEV Requirements: Implementation

In calculating emission reductions resulting from the ZEV requirements, 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 Oregon for each category (cars and light trucks) were estimated based on year 2003 new vehicle registration figures from Alliance of Automobile Manufacturers, *Light Truck Country*, downloaded from autoalliance.org/archives/000141.html, 27 August 2004, with the light truck category divided into heavy and light light-duty trucks using EPA fleet composition estimates as described above. These figures were then multiplied by the percentage of sales subject to the ZEV requirements for each year.
- This number was multiplied by 0.9 to account for the six-year time lag in calculating the sales base subject to the ZEV requirements. (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 ZEV requirements entirely by supplying PZEVs.)
- This value was then multiplied by the percentage sales requirement to arrive at the number of ZEV 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 Oregon 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 Oregon.

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 ZEV requirements, 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 ZEV requirements are depicted in Figure 6 (assuming a roughly 60/40 percentage split between light-truck sales and car sales throughout the entire period).

Fleet Emissions Projections

Based on the above data, three scenarios were created: a "Base Case" scenario based on projected trends in vehicle fuel economy, VMT and vehicle mix; a "ZEV Requirements" scenario based on the implementation scenario described above; and a "Global Warming Pollution Standards" scenario based on the percentage emission reductions proposed by the CARB staff in August 2004. Each scenario began with data from 2000 and continued through 2020.

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

Other Assumptions

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

- **Rebound effects** – Research has shown that improved vehicle fuel efficiency often results in an increase in vehicle-miles traveled. By reducing the marginal cost of driving, efforts to improve efficiency provide an economic incentive for additional vehicle travel. Studies have found that this "rebound effect" may reduce the carbon dioxide emission savings of fuel economyimproving policies by as much as 20 to 30 percent.[40] 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.[41]

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

Notes

1. *Scientific Consensus Statement on the Likely Impacts of Climate Change in the Pacific Northwest.* June 2004.

2. Intergovernmental Panel on Climate Change, *IPCC Third Assessment Report—Climate Change 2001: The Scientific Basis, Summary for Policy Makers*, 2001.

3. Governor's Advisory Group on Global Warming. *Oregon Strategy for Greenhouse Gas Reductions.* State of Oregon, December 2004.

4. Mote, P.W. 2004. "Trends in temperature and precipitation in the Pacific Northwest during the twentieth century." *Northwest Science* 77(4): 271-282. Cited in *Scientific Consensus Statement on the Likely Impacts of Climate Change in the Pacific Northwest.* June 2004.

5. See note 2.

6. Robert Roy Britt, "Surprising Side Effects of Global Warming," *Live Science*, 22 December 2004, downloaded from www.livescience.com/forcesofnature/041222_permafrost.html, 27 September 2005.

7. "Global Warming Fast Facts," *National Geographic News,* downloaded from news.nationalgeographic.com/news/2004/12/1206_041206_global_warming_2.html, 27 September 2005.

8. See note 1.

9. Ibid.

10. See notes 1 and 3.

11. See note 1.

12. See notes 1 and 3.

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

14. See note 3.

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

16. Oregon Department of Transportation. Data transmitted electronically by David Kavanaugh. July 15, 2005.

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

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

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

20. 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.

21. See note 19.

22. Ibid.

23. Total global warming emissions of 68.6 $MMTCO_2E$ from Governor's Advisory Group on Global warming, *Oregon Strategy for Greenhouse Gas Reductions, Appendix B*, December 2004.

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

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

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

27. 2004 sales: Toyota, *Toyota Reaches Two Million in Sales For The First Time in 47-Year History* (press release), 4 January 2005; Honda, *American Honda Sets New All-Time Sales Record* (press release), 4 January 2005; and Steve Geimann, *Bloomberg*, "Ford Expands Lineup of Gas-Electric Hybrid Vehicles (Update 3)," 9 January 2005. 2003 sales: John Porretto, "High Fuel Prices Pumping Up Hybrid Sales," *Associated Press,* 9 May 2004.

28. 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.

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

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

31. 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.

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

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

34. 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.

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

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

37. 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.

38. See note 34.

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

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

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