

# CARS AND GLOBAL WARMING:

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



**Arizona PIRG** Education  
Fund

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# EXECUTIVE SUMMARY

**A**rizona could limit its contribution to global warming over the next two decades by implementing policies to reduce carbon dioxide emissions from cars and light trucks.

Global warming poses a serious threat to Arizona's future. Scientists project that average temperatures in Arizona could increase by 2° to 9° F over the next century if no action is taken to reduce global warming pollution. Warmer temperatures in Arizona could shrink fresh water supplies, cause increased deaths from air pollution and heat, spread mosquito-borne illnesses, and impact Arizona's economy, public health and environment in a host of other ways.

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

Transportation-related emissions are responsible for approximately 39 percent of Arizona's global warming pollution. Cars and light trucks—such as pickups, minivans and SUVs—are the most important sources of global warming pollution within the transportation sector, responsible for approximately 60 percent of all emissions from transportation and more than one-fifth of Arizona's total emissions of global warming pollution.

**Carbon dioxide pollution from cars and light trucks in Arizona could double from 1990 to 2020 unless action is taken to reduce emissions.**

- Emissions already have increased by nearly 40 percent from 1990 to 2000 and are projected to rise by an additional 59 percent from 2000 to 2020.
- The stagnation in federal corporate average fuel economy (CAFE) stan-

dards for cars and light trucks, the recent shift toward greater use of less fuel-efficient SUVs, and increasing vehicle travel have put Arizona on a course toward dramatically increased emissions of carbon dioxide from transportation over the next two decades.

**Arizona can significantly reduce carbon dioxide pollution from cars and light trucks by adopting the Clean Cars Program.**

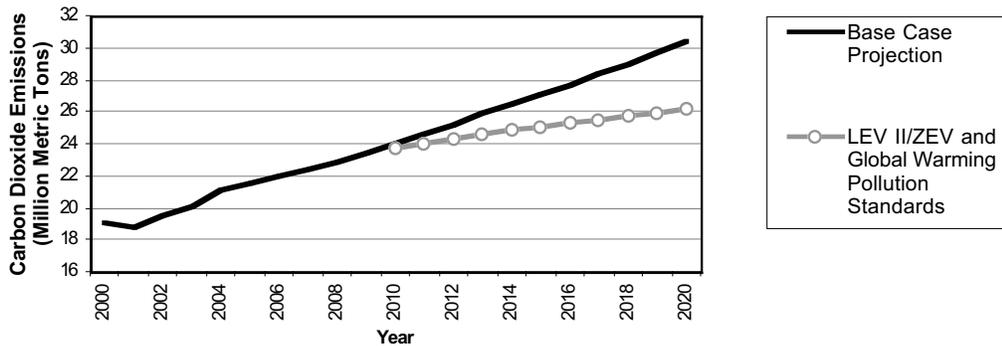
- The Clean Cars Program establishes limits on health-damaging pollution and global warming pollution from automobiles. It will pave the way for the widespread introduction of technologies like hybrid-electric and fuel-cell vehicles, direct-injection engines, advanced transmissions, improved air conditioning systems, and other technologies with the potential to reduce pollution. The program is made up of the Low Emission Vehicle II and Zero Emission Vehicle (LEV II/ZEV) standards for health-damaging pollution and standards for global warming pollution.
- By implementing the program to take effect in model year 2011 (calendar year 2010), Arizona could reduce carbon dioxide pollution from cars and light trucks by about 14 percent below projected levels by 2020. (See Figure ES-1.)
- 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 standards—and more if gasoline prices remain high.
- Even with implementation of both components of the Clean Cars Pro-

gram, carbon dioxide pollution from cars and light trucks in 2020 would remain 37 percent higher than in 2000 because of a large projected increase in vehicle travel. Thus, Arizona will need to adopt additional policies to stabilize and reduce emissions from the transportation sector.

Arizona should move quickly to adopt policies that will stabilize and ultimately reduce carbon dioxide pollution from cars and light trucks.

- Arizona should adopt the Clean Cars Program so that it takes effect in model year 2011.
- Arizona should adopt additional programs—such as clean car incentives that encourage individuals and fleets to purchase vehicles with lower global warming emissions, policies that reduce vehicle travel, transit improvements and other measures—that reduce global warming pollution from the transportation sector.

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



# INTRODUCTION

**A**cross the Southwest and the world as a whole, there is a growing consensus that action to reduce global warming pollution is necessary and urgent. Global warming threatens to significantly increase the average temperature in Arizona, causing dramatic changes in our economy and quality of life.

Recognizing the threat global warming poses to Arizona, Governor Napolitano issued an executive order in February 2005 creating a Climate Change Advisory Group to provide recommendations on how Arizona can reduce its emissions of global warming pollution. The Advisory Group, which includes representatives from electricity producers, mining and agriculture interests, tribes, environmental organizations, local governments and others, is expected to present its findings in June 2006.

Among its initial steps, the Advisory Group assembled an inventory of the largest sources of global warming pollution in Arizona. From this inventory, the transportation sector emerges as one of Arizona's biggest challenges. Not only is transportation a major source of the state's global warming pollution but emissions from the transportation sector are expected to rise in coming years. In particular, cars and light trucks stand out as the largest sources of transportation emissions.

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

To ensure that these technologies play a role in Arizona's global warming strategy, one of the policies that should be included in the Climate Change Advisory Group's recommendations and that the state should adopt is the Clean Cars Program.

The Clean Cars Program has been adopted by 10 states including Oregon, New York, Connecticut, Massachusetts, and New Jersey. The first provision of the program, the Low-Emission Vehicle II and Zero-Emission Vehicle (LEV II/ZEV) standards, requires that a percentage of vehicles sold in Arizona in coming years be advanced-technology vehicles such as hybrids, which have lower global warming emissions.

The second part of the Clean Cars Program sets limits on vehicle global warming pollution. Automakers will reduce emissions of global warming pollutants by incorporating direct-injection engines, continuously variable transmissions, improved air conditioners, and other advanced technologies into new vehicles. Standards for vehicle global warming pollution will further reduce the impact of our transportation system on the climate.

This report documents how the Clean Cars Program could reduce projected global warming pollution from light-duty vehicles in Arizona. It estimates the impact of both LEV II/ZEV and vehicle global warming pollution standards on overall global warming pollution from motor vehicles in Arizona. But it also documents the challenge the state faces in reining in emissions from the transportation sector. Even with full implementation of the Clean Cars Program, Arizona will still need to take additional steps to curtail global warming pollution from transportation.

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

## Causes of Global Warming

Global warming is caused by increasing concentrations of greenhouse gas pollution in the atmosphere that trap 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 1850, the atmospheric concentration of carbon dioxide has increased by approximately 30 percent.<sup>1</sup> The current rate of increase in carbon dioxide concentrations is unprecedented in the last 20,000 years and the total concentration of carbon dioxide is at its highest point in 400,000 years.<sup>2</sup> 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 roughly 1° F.<sup>3</sup> If current trends in global warming pollution continue, temperatures could rise by an additional 2.5° F to 10.4° F over the period 1990 to 2100.<sup>4</sup>

## Potential Impacts of Global Warming

The impact of this increase in global temperatures will vary from place to

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

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

Over the last century, the average temperature in Tucson has increased by 3.6° F.<sup>5</sup> Meanwhile, precipitation has increased by 20 percent in much of Arizona, with the exception of northwestern Arizona, where precipitation has declined by 20 percent.<sup>6</sup>

Should current emission trends continue, some studies predict that temperatures in Arizona could increase by 2° F to 9° F by 2100.<sup>7</sup>

Precipitation levels also could change. Scientific models suggest precipitation may decrease by up to 15 percent in the summer and increase at other times of year, particularly in winter when precipitation could increase by 60 percent.<sup>8</sup> Days with very heavy rain or snowfall could increase.

In any event, the impacts of such a shift in average temperature and precipitation would be severe.<sup>9</sup> The potential impacts of global warming in Arizona are varied:

- Mosquito and tick-borne illnesses, such as malaria and San Joaquin Valley fever, could spread. Mice, which can carry the virus that causes hantavirus pulmonary syndrome, may thrive as precipitation patterns change.

- The risk of heat-related illnesses and deaths and of respiratory disease may rise. Air quality may worsen as higher temperatures facilitate the formation of ground-level ozone that presents a respiratory threat.
- Fresh water supplies may decline and water pollution may worsen. Snowpacks could melt earlier in the year, evaporation could increase, and aquifer replenishment rates could slow, threatening water supplies. Salinity and pollution concentrations could increase, aggravating water quantity problems.
- Flood risks could increase, as rapid snowmelts force the release of large volumes of water from Arizona's water control systems, and as El Niño events, which bring increased rain, become more frequent.
- The amount of forested land may decline by as much as 15 to 30 percent, and wildfires may become more common as mild winters permit greater insect infestation that creates large areas of dead or weakened trees.
- Changing precipitation patterns could harm economically important sectors such as ranching. Greater annual variability in rainfall could reduce the productivity of pastureland, straining ranchers' ability to earn a reliable living.

Temperatures may gradually rise, changing precipitation patterns, plant and animal distribution and storm patterns over the course of decades, or higher temperatures may trigger a more sudden change in the earth's climate.

Historically, the climate has experienced large shifts in a single decade. Approximately 12,500 years ago, the earth's climate changed dramatically. In some places, temperatures may have

fallen by as much as 10° F in just 10 years.<sup>10</sup> Frigid conditions persisted for roughly 1,000 years before returning to more normal temperatures. Scientists do not fully understand the cause of these changes but theorize that a seemingly gradual shift may cross a climate threshold and trigger rapid alterations.<sup>11</sup> For example, increased carbon dioxide concentrations may prompt enough warming to cause permafrost to melt, releasing trapped methane. Methane is a potent greenhouse gas and could trigger much bigger increases in global warming.

Both the severity and timing of global warming and its potential impacts are difficult to predict. But this much is certain: projected changes in climate would have a dramatic, disruptive effect on Arizona's economy, public health and environment. Arizona needs to take immediate action to limit emissions of global warming pollutants such as carbon dioxide and do its part to return atmospheric concentrations of global warming gases to levels that will stabilize the climate.

## Global Warming Pollution in Arizona

Carbon dioxide emitted from fossil fuel use is the leading cause of global warming. In 2000, fossil fuel use and industrial and agricultural activity in Arizona resulted in the release of 89 million metric tons of carbon dioxide equivalent (MMT<sub>CO<sub>2</sub>E</sub>, see note on units on p. 10).

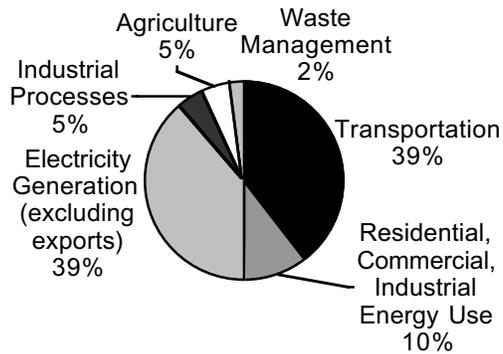
The transportation sector is responsible for approximately 39 percent of Arizona's releases of global warming pollution.<sup>12</sup> (See Figure 1.) Cars and light trucks—such as pickups, minivans and SUVs—are the most important sources of global warming pollution within the transportation sector, responsible for

approximately 60 percent of all transportation-sector emissions and more than one-fifth of Arizona's total emissions of global warming pollution.<sup>13</sup>

## Global Warming Reduction Efforts in Arizona

Recognizing the threat global warming poses to Arizona, Governor Napolitano issued an executive order in February 2005 creating a Climate Change Advisory Group to provide recommendations on how Arizona can reduce its emissions of global warming

**Figure 1. Arizona Sources of Global Warming Emissions in 2000<sup>14</sup>**



pollution.<sup>18</sup> The Advisory Group, which includes representatives from business, farming, environmental organizations,

### Other Global Warming Pollutants

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

- **Methane** – Methane gas is likely the second most important contributor to global warming. Cars and light trucks produce methane in their exhaust, but it is thought that they are only minor emitters of methane and that pollution will be reduced in the future through improved emission control systems.<sup>15</sup>

- **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.<sup>16</sup> As with methane emissions, improved pollution control measures may reduce nitrous oxide emissions in the future.

- **Hydrofluorocarbons (HFCs)** – HFCs are extremely potent global warming gases, yet tend to be released in only very small quantities. HFCs are often used as coolants in vehicle air conditioning systems and can escape from those systems into the environment.

- **Black carbon** – Black carbon, otherwise known as “soot,” is a product of the burning of fossil fuels, including diesel fuel used in heavy-duty trucks and a small percentage of light-duty vehicles. Recent research has suggested that, because black carbon absorbs sunlight in the atmosphere and on snow and icepack, it may be a major contributor to global warming, perhaps second in importance only to carbon dioxide. Research is continuing on the degree to which black carbon pollution contributes to global warming.<sup>17</sup>

## 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 document emissions in terms of carbon dioxide equivalent or, when we are measuring emissions of carbon dioxide only, in terms of carbon dioxide. Other documents may communicate pollution in terms of “carbon equivalent.” To translate carbon equivalent to carbon dioxide, one can simply multiply by 3.66.

tribes and local governments, has begun meeting to evaluate emission-reduction options for Arizona and is expected to present its findings in June 2006.

Arizona is already taking several steps to begin reducing its global warming emissions. In 2005, the state adopted efficiency standards for 12 common residential and commercial appliances.<sup>19</sup> The state is moving toward increasing its environmental portfolio standard for electricity generation, which will require a greater percentage of the state’s electricity to come from new, clean renewable resources.<sup>20</sup> In addition, the state offers a tax exemption and tax credit on the purchase of solar electric and heating equipment.

## Transportation and Global Warming: A Primer

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

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

1. Drive more efficient vehicles.
2. Reduce the number of miles traveled (see p. 21 for further discussion).
3. Switch to fuels with a lower carbon content, such as biofuels containing ethanol (see p. 20 for further discussion).

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 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 Arizona even greater.

### Increasing Vehicle Miles Traveled

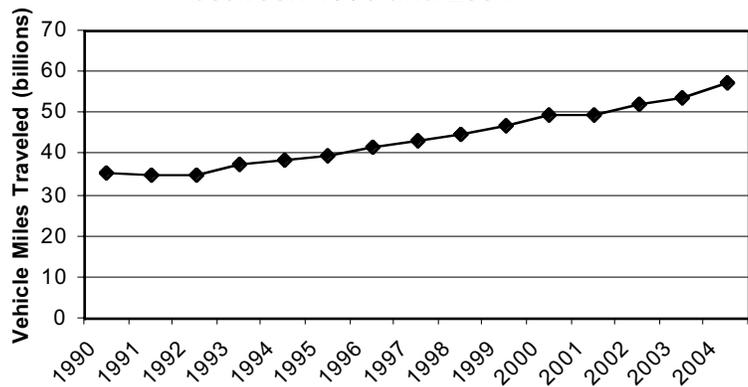
Arizona residents are traveling more miles in their cars and light trucks than ever before. Between 1990 and 2004, the number of vehicle-miles traveled (VMT) annually on Arizona's roads increased from 35.5 billion miles to 57.3 billion miles—an increase of 61 percent.<sup>21</sup> (See Figure 2.) From 2004 to 2020, VMT is projected to increase another 53 percent to 87.5 billion miles.<sup>22</sup>

### 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.<sup>24</sup> (The National Highway Traffic Safety Administration has begun to phase in an increase in the light truck standard to 22.2 mpg, to be fully achieved by model year 2007.)

In the decade-and-a-half following enactment of the CAFE standards, the “real world” fuel economy of passenger cars nearly doubled—from 13.4 mpg in 1975

Figure 2. Arizona VMT Increased 61 Percent between 1990 and 2004<sup>23</sup>



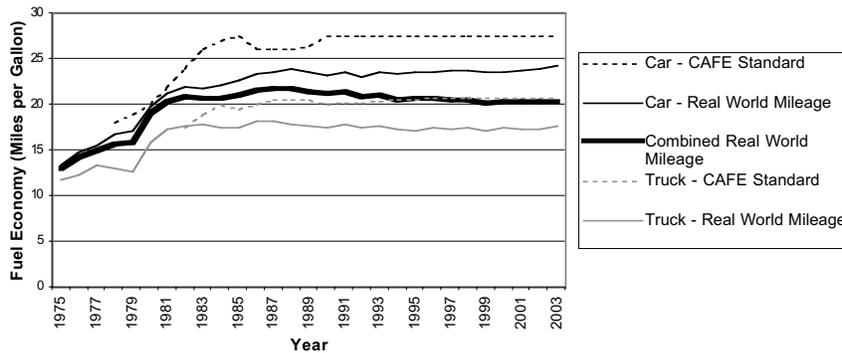
to 24.0 mpg in 1988. Similarly, light trucks experienced an increase in real-world fuel economy from 11.8 mpg in 1975 to 18.3 mpg in 1987.<sup>25</sup>

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

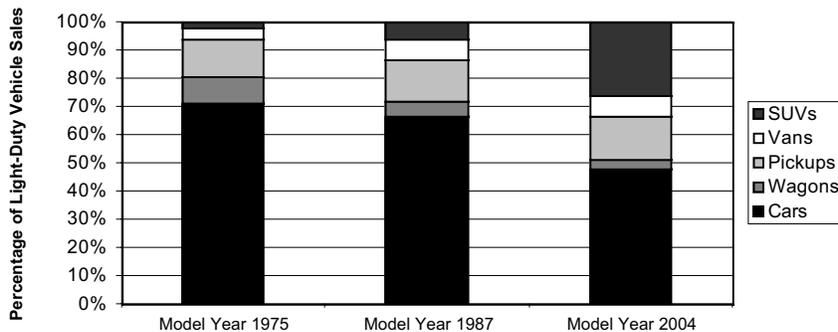
Until recently, the federal government had failed to increase CAFE standards for more than a decade. To make matters worse, changes in driving patterns, including higher speeds and increased urban driving, have led to a real-world decrease in fuel economy. An EPA analysis of fuel economy trends found that the 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.<sup>26</sup> (See Figure 3.)

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

**Figure 3. Average Fuel Economy for New Light-Duty Vehicle Fleet on the Decline<sup>27</sup>**



**Figure 4. Light-Duty Vehicle Mix Shifts from Cars to Trucks, Vans and SUVs**



that could cost-effectively improve fuel economy, even a modest increase in CAFE standards has some effect in reducing the rate of growth of transportation carbon dioxide pollution.

### Growing Numbers of SUVs and Light Trucks

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

In 1975, when the first federal CAFE standards were enacted, SUVs made up 2 percent of the light-duty vehicle market, vans 5 percent, and pickup trucks

13 percent. By model year 2004, however, SUVs accounted for 26 percent of light-duty vehicle sales, vans 7 percent, and pickup trucks 15 percent. The light-duty market share of passenger cars and station wagons dropped over the same period from 81 percent to 52 percent.<sup>28</sup> (See Figure 4.)

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.<sup>29</sup>

The trend toward SUVs and light trucks could continue, with light trucks making up an increasing percentage of the entire light-duty fleet as time goes on. The Environmental Protection Agency projects that by 2020, 64 percent of all light-duty vehicles on the road will be light trucks.<sup>30</sup> Recent increases in gasoline prices have slowed sales of SUVs, but it is too early to determine if the long-term shift toward SUVs and light trucks will change significantly. (Manufacturers have promoted “cross-over” vehicles as an alternative to SUVs, but because these vehicles are classified as light trucks, their fuel economy is not necessarily better than that of conventional SUVs.)

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

## Vehicle Carbon Dioxide Pollution in Arizona: Past and Projected

Based on Arizona-specific fuel consumption data compiled by the U.S. Energy Information Administration (EIA), cars and light-duty trucks released approximately 13.7 million metric tons of carbon dioxide into the atmosphere in 1990. By 2000, those emissions had increased by about 39 percent, to 19.1 MMTCO<sub>2</sub>—meaning that cars and trucks were responsible for more than one-fifth of Arizona’s emissions of global warming pollution in 2000.

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

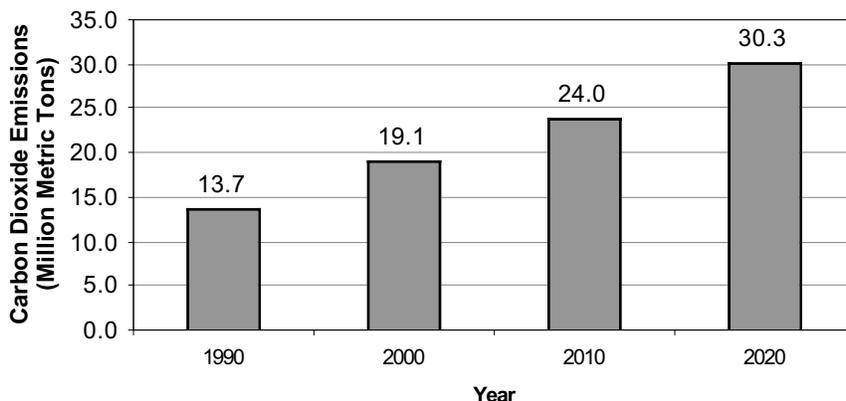
Based on these assumptions, carbon dioxide emissions from the Arizona light-duty vehicle fleet are projected to increase 25 percent over 2000 levels by 2010, followed by a further 27 percent increase between 2010 and 2020. In other words, by 2020, carbon dioxide emissions from cars and light trucks could be more than double 1990 levels in the absence of action to reduce emissions. (See Figure 5.)

An increase of such magnitude would severely challenge Arizona’s ability to stabilize and eventually reduce global warming pollution from the transportation sector and the state as a whole. Should these increases in emissions from cars and light trucks occur, Arizona 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, a level of reduction estimated by scientists as necessary to limit any dangerous threat to the climate.<sup>31</sup>

However, this path toward increasing carbon dioxide pollution from cars and light trucks is not inevitable. Public policies that require or encourage the purchase of more fuel-efficient or advanced technology cars can make a significant dent in Arizona’s future emissions of global

warming pollution while potentially saving money for drivers. One of the most powerful policy options is setting limits on vehicle global warming pollution.

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



# TOOLS TO REDUCE GLOBAL WARMING POLLUTION FROM CARS AND LIGHT TRUCKS

Arizona has many potential tools available to reduce emissions of global warming pollution from the transportation sector. In addition to greater efforts to promote alternatives to driving, such as the light rail system planned for Maricopa County, the state should use one of the most powerful tools it has available: global warming pollution standards for cars and trucks.

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

Ten states—New Jersey, New York, Massachusetts, Connecticut, Rhode Island, Vermont, Maine, Oregon, Washington and California—have adopted or moved toward adoption of the Clean Cars Program, including the vehicle global warming emission standards, and others are considering it.

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

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

## LEV II/ZEV Standards

The first stage of the Clean Cars Program—known as the Low-Emission Vehicle II and Zero Emission Vehicle, or LEV II/ZEV, standards—seeks to reduce emissions of smog-forming and other hazardous pollutants. It achieves its goals by establishing fleet-wide limits on tailpipe emissions and by requiring the sale of advanced-technology vehicles such as hybrids that have even lower emissions. Eventually, the program calls for the sale of zero-emission vehicles (ZEVs). In addition, some of the technological changes encouraged by LEV II/ZEV will reduce emissions of global warming pollutants.

By adopting the program, Arizona can expect to have increasing percentages of advanced-technology vehicles on the road over the next decade and more. The ZEV portion of the program, which will help reduce global warming pollution in addition to curbing emissions of toxic air pollution, has three main components, as described below.

### **Pure Zero-Emission Vehicles**

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

The most recent revision to the ZEV program 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 Arizona until at least model year 2012. Even then, the number of pure ZEVs required for sale in Arizona would be small, representing less than one percent of new car and light truck sales until model year 2016.<sup>32</sup>

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.<sup>33</sup>

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

### ***Partial Zero-Emission Vehicle (PZEV) Credits***

The majority of vehicles that automakers produce to comply with the ZEV standard 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 Arizona to achieve its air quality goals, the technologies used in PZEVs do not necessarily make a substantial contribution to reducing global warming pollution from cars. Thus, we do not assume any global warming benefits from the PZEV portion of the program.

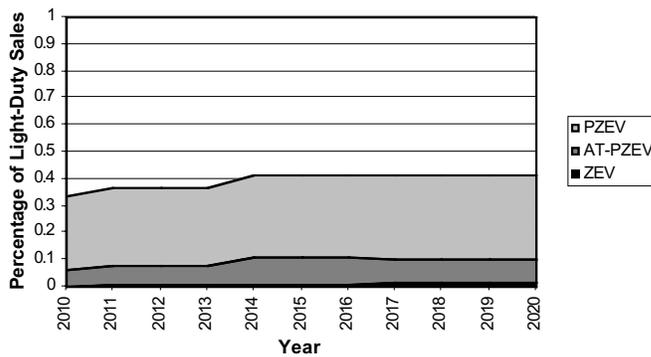
### ***Advanced Technology PZEVs (AT-PZEVs)***

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

Hybrid-electric vehicles are the most likely technology to be used to comply with AT-PZEV standards. Hybrids have proven to be very popular with consumers, especially in an era of higher and rapidly fluctuating gasoline prices. Sales of hybrid vehicles have increased steadily since their introduction to the domestic market in December 1999. About 85,000 hybrids were sold in the U.S. in 2004, almost double the sales of the previous year.<sup>34</sup> And in just the first six months of 2005, nearly 93,000 hybrid vehicles were sold in the U.S.<sup>35</sup>

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.<sup>36</sup> (Several other hybrid vehicles, such as the Honda Accord, are on the market but either their emissions are too high to meet AT-PZEV standards or the automaker does not want to offer the extended warranty required with PZEVs. These vehicles nonetheless can achieve measurable reductions in global warm-

**Figure 6. ZEV Program Percentage of Light-Duty Vehicle Sales, 2010 through 2020**



ing emissions.) Unfortunately, although a healthy market for hybrids appears to exist, automakers have not yet supplied hybrids in large enough quantities to meet consumer demand. The demand crunch could ease slightly if automakers introduce additional hybrid models as planned—including hybrid versions of the Nissan Altima and Toyota Camry—that could qualify for AT-PZEV credit.<sup>37</sup>

Should automakers choose to maximize their use of AT-PZEVs to comply with the ZEV program—and do so using vehicles similar to the Toyota Prius—hybrids could make up about 6.3 percent of Arizona car and light truck sales in 2010, increasing to 7.1 percent by 2012. (See Figure 6.) This translates to sales of about 18,000 hybrids in Arizona in 2010, increasing to approximately 29,000 annually by 2016. Because the ZEV program offers a great deal of flexibility, however, automakers could choose to comply by manufacturing greater numbers of less-advanced hybrids or smaller numbers of pure ZEVs, among other options.

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 program does provide additional credit to hybrid-electric vehicles that attain a greater share of their power from an electric motor (generally allowing them to achieve lower carbon dioxide emissions), but these credits are not directly tied to global warming pollution. For the purposes of this analysis, we assume that hybrids manufactured to comply with AT-PZEV standards will release about 30 percent fewer global warming gases per mile than conventional vehicles.<sup>38</sup>

### ZEV Program Impacts: Long Term

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

An example of the potential power of the program to hasten technological change is the development of hybrid vehicles. Adoption of the original ZEV program sparked public and private-sector

research efforts into the development of advanced batteries and electric-drive technologies. While the 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.<sup>39</sup>

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

### ZEV Program Impacts: Short Term

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

We assume that automakers will take maximum advantage of the ability to meet ZEV program requirements with PZEVs and AT-PZEVs. We also assume that vehicles sold to meet AT-PZEV re-

quirements 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 Arizona beginning in the 2011 model year (calendar year 2010) would reduce light-duty vehicle carbon dioxide emissions by about 1.5 percent versus base case projections by 2020—for a total reduction in emissions of about 0.47 MMTCO<sub>2</sub>. (See Figure 7.) This relatively small reduction is a side benefit of measures in the ZEV program to reduce toxic air emissions.

Arizona’s adoption of the Clean Cars Program will result in reduced global warming and toxic pollution from vehicles as the ZEV standard takes effect. Implementing the program’s vehicle global warming pollution standards will provide even greater emission reductions.

**Figure 7. Projected Reductions in Carbon Dioxide Emissions Under the ZEV Program (Light-Duty Vehicles)**

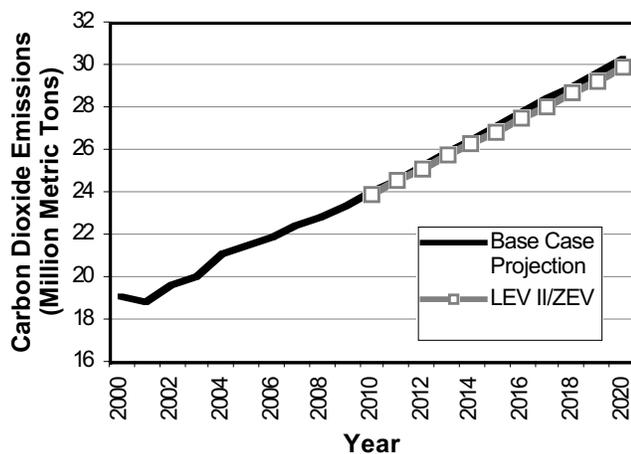




Photo: Sandy Ridlington

## Vehicle Global Warming Pollution Standards

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

The standards require CARB to propose limits that “achieve the maximum feasible and cost effective reduction of greenhouse gas emissions from motor vehicles.” Limits on vehicle travel, new gasoline or vehicle taxes, or limitations on ownership of SUVs or other light trucks cannot be imposed to attain the new standards.<sup>40</sup> In September 2004, CARB adopted rules for implementation of the global warming pollution standards. 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.<sup>41</sup>

The technological changes needed to achieve these reductions (such as five and six-speed automatic transmissions and improved electrical systems) will likely result in modest increases in vehicle costs that would be more than recouped over time by consumers in the form of reduced fuel expenses. CARB projects that cars and the lightest light trucks attaining the 34 percent reduction in global warming pollution required by 2016 would cost an average of \$1,064 more for consumers, while heavier light trucks achieving the required 25 percent reduction would cost about \$1,029 more.<sup>42</sup>

However, the agency also estimates that the rules will significantly reduce operating costs for new vehicles. Though consumers will face higher monthly loan payments when purchasing vehicles that comply with the standards, those increased costs will be more than offset by lower operating expenses. For example, a consumer who buys a new car in 2016 will pay \$20 more per month on the car loan but will save \$23 per month in operating expenses, for a total savings of \$3 per month. After the loan is paid off, the consumer will save the full \$23 per month. Drivers who purchase a light truck or who pay for the vehicle in cash will experience greater savings.<sup>43</sup> (See Table 1.) These savings assume gasoline costs of \$1.74 per gallon.<sup>44</sup> Higher gasoline prices will increase the savings to consumers. (See Table 2). CARB also projects that the net impact of the standards to the state’s economy will be positive, suggesting that Arizona could save money while at the same time reducing the state’s overall emissions of global warming gases.<sup>45</sup>

Assuming that Arizona adopts the standards beginning with the 2011 model year, the resulting reductions in global warming pollution would be significant. Compared to the base case projection, the emission standards would reduce light-duty carbon dioxide emissions by 13.7 percent by 2020—for a total reduction of 4.1 MMTCO<sub>2</sub>. (See Figure 8.)

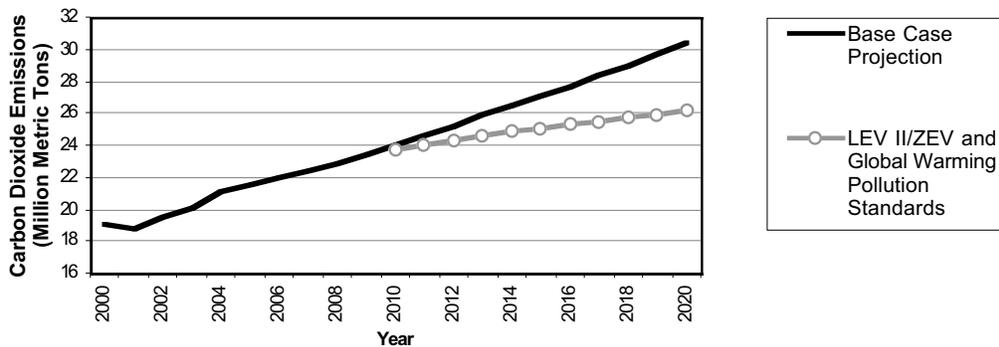
Adopting the Clean Cars Program can contribute significantly to efforts to reduce global warming pollution from Arizona’s transportation sector. With both components in effect, emissions from light-duty cars and trucks would be 37 percent greater in 2020 than they were in 2000, compared to 59 percent greater if no action is taken.

**Table 1. Net Savings for Consumer Under Global Warming Pollution Standards in 2016<sup>46</sup>**

|                                  | 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         |

Yet, while the Clean Cars Program will provide a strong start to Arizona’s efforts to reduce global warming pollution, the state will need to complement the program with other policies to stabilize and ultimately reduce emissions.

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



**Table 2. Greater Net Savings for Consumer at Higher Gas Prices<sup>47</sup>**

|  | \$1.74 gallon | \$2.20 per gallon | \$3.00 per gallon |
|--|---------------|-------------------|-------------------|
| Annual Net Savings while Repaying Loan | \$41-\$81     | \$115-\$170       | \$245-\$320       |
| Annual Net Savings after Loan          | \$282-\$314   | \$360-\$410       | \$490-\$560       |
| Time to Recoup Higher Cost of Vehicle  | 3.7-4.3 years | 2.9-3.4 years     | 2.2-2.5 years     |

## POLICY FINDINGS

Attaining reductions in carbon dioxide emissions will require significant actions to reduce emissions from light-duty vehicles. No one policy will solve the problem. Arizona will need to pursue a range of policies to address the current lack of standards for vehicle global warming pollution, increasing vehicle miles traveled and growing numbers of SUVs and light trucks.

The first step Arizona should take is to adopt the Clean Cars Program for implementation in model year 2011, establishing vehicle global warming pollution standards. This will slow the growth in global warming pollution from light vehicles, but to reduce pollution to a level that will protect the climate, the state will need to adopt additional policies.

Options include other policies to cut the amount of global warming pollution released by vehicles per mile and reducing the number of vehicle miles traveled.

### **Reducing Per-Mile Emissions from Vehicles**

The Clean Cars Program is the biggest step Arizona can take to reduce global warming emissions from vehicles. Other policies can provide additional benefits.

### **Encourage the Purchase of Lower-Carbon Vehicles**

The state should create incentives for individuals and fleets to purchase vehicles with lower carbon emissions. One possible approach is to offer incentives that would give a rebate to car buyers who purchase vehicles that emit less global warming pollution. In addition to hy-

brid cars, any vehicle that offers below-average global warming emissions potentially could qualify (provided that emissions of other pollutants, such as diesel particulate matter, do not contribute to air quality problems). The rebate could be funded by a fee on purchasers of less efficient vehicles and thus could be revenue neutral for the state. Connecticut and several other New England states are considering such a program.<sup>48</sup>

### **Promote Biofuels**

Biofuels are typically made from such crops as corn, soybeans, canola, rapeseed, or even mustard seed. The global warming impact of biofuels is much lower than petroleum fuels. Crops temporarily remove carbon from the atmosphere as they grow and return it when they decay or are burned. In contrast, burning fossil fuels releases carbon that had been removed from the atmosphere thousands of years ago.

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

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

## **Reducing Growth in Vehicle Travel**

### **Improve Transit Service**

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

Employers can help organize and promote ride-sharing programs by pairing drivers with similar commutes, offering preferred parking to carpools, and providing a ride home if an employee has a mid-day emergency or needs to stay at work late. Large employers also can reduce single-occupant commuting by helping to fund transit systems that serve employees.

### **Expand Walking and Biking Options**

Many trips can be completed on foot or bicycle instead of in a car, but lack of safe routes for walking or cycling deters

people. Though summer temperatures may be too hot, during much of the year Arizona has ideal conditions for walking and cycling. Sidewalks with pedestrian amenities such as benches and trees, and shops oriented toward customers on foot rather than in cars can encourage more people to walk. Changes to road design can slow traffic, making it easier and safer for pedestrians and cyclists to cross busy intersections.

### **Link Insurance to Miles Driven**

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

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

### **Promote Smart Growth**

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

# ASSUMPTIONS AND METHODOLOGY

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

## Baseline Light-Duty Vehicle Carbon Dioxide Emissions

Carbon dioxide emissions from light-duty vehicles (cars and light trucks) in Arizona 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*.<sup>49</sup> 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 Arizona were obtained from the Arizona Department of Transportation, *Highway Performance Monitoring System*, downloaded from [tpd.azdot.gov/datateam/hpms.php](http://tpd.azdot.gov/datateam/hpms.php), 25 October 2005. Projected VMT was calculated using the projected growth in VMT from 2002 to 2025 as

presented in Cambridge Systematics, Inc, for Arizona Department of Transportation, *MoveAZ: Long Range Transportation Plan*, September 2004.

## VMT Percentages by Vehicle Type

To estimate the percentage of vehicle-miles traveled accounted for by cars and light-duty trucks, we relied on two sources of data: actual VMT splits by vehicle type for 2000 through 2002 from the Federal Highway Administration, *Highway Statistics* series of reports and projections of future VMT splits output from the EPA's MOBILE6 mobile source emission estimating model.

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

EPA's projections of the VMT split among cars and light-duty trucks assign significantly more VMT to light-duty trucks than has been the case over the past several years, according to FHWA data. Recent rises in fuel prices have prompted more consumers to purchase cars instead of trucks than has been the case for several years, but it is too early to predict how long or significant this trend might be. Further, the change in

vehicle buying habits has been less pronounced in Arizona.<sup>50</sup> Thus, for this analysis, we incorporate EPA's long-term projection that light trucks will represent an increasing portion of light-duty vehicle sales.

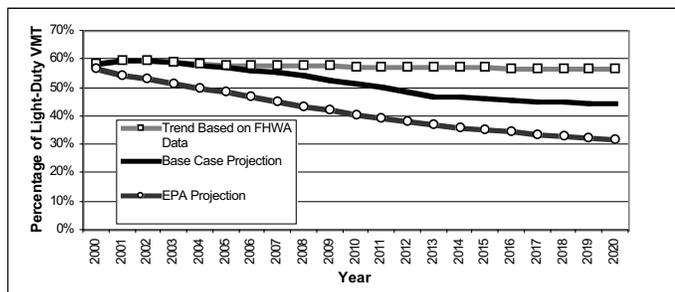
In order to estimate a trend that reflects both the more car-heavy current makeup of VMT and the long-term trend toward increasing travel in light trucks, we created two curves, one extrapolating the continued linear decline in the car portion of light-duty VMT based on trends in FHWA data from 1990 to 2004 and another using the EPA MOBILE6 estimates. We then assumed that the split in VMT would trend toward the EPA estimate over time, so that by 2020, cars are responsible for approximately 45 percent of light-duty VMT. (See Figure 9.)

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

### VMT Percentages by Vehicle Age

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

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



### Vehicle Carbon Dioxide Emissions

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

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

For hybrid-electric vehicles used to comply with AT-PZEV requirements, fuel economy was estimated to exceed that of conventional vehicles by 30 percent, per National Research Council, National Academy of Engineering, *The Hydrogen Economy: Opportunities, Costs, Barriers and R&D Needs*, the National Academies Press, 2004. This same document provided the assumption that hydrogen fuel-cell vehicles would achieve 58 percent greater fuel economy than conventional vehicles. This figure was then input into the Argonne National Laboratory's Greenhouse Gases Regulated Emissions and Energy Use in Transportation (GREET) model version 1.5a to produce an estimated grams CO<sub>2</sub>/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 Arizona. Estimated emissions from electricity used to generate hydrogen were not adjusted for Arizona'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 Program Implementation

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

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

- Light-duty vehicle sales in Arizona for each category (cars and light trucks) were estimated based on year 2004 new vehicle registration figures from Alliance of Automobile Manufacturers, *Light Truck Country*, downloaded from [autoalliance.org/download/lighttruck.pdf](http://autoalliance.org/download/lighttruck.pdf), 27 October 2005, with the light truck category divided into heavy and light light-duty trucks using EPA fleet composition estimates as described above. These figures were then multiplied by the percentage of sales subject to the ZEV program for each year.
- This number was multiplied by 0.9 to account for the six-year time lag in calculating the sales base subject to the ZEV program. (For example, a manufacturer's requirements in the 2009 through 2011 model years are based on percentages of sales during model years 2003 through 2005.)
- Where necessary, these values were multiplied by the percentage of vehicles supplied by major manufacturers versus all manufacturers as calculated from Ward's Communications, *2003 Ward's Automotive Yearbook*, 233. (Non-major manu-

facturers may comply with the entire ZEV program requirement by supplying PZEVs.)

- This value was then multiplied by the percentage sales requirement to arrive at the number of ZEV program credits that would need to be accumulated in each model year.
- The credit requirement was divided by the number of credits received by each vehicle supplied as described in California Environmental Protection Agency, Air Resources Board, *Final Regulation Order: The 2003 Amendments to the California Zero Emission Vehicle Regulation*, 9 January 2004.
- The resulting number of vehicles was then divided by total light-duty vehicle sales to arrive at the percentage of sales required of each vehicle type.
- No pure ZEVs were assumed to be required for sale in Arizona 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 Arizona.

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 ZEV program, manufacturers have the flexibility to use credits accumulated from the sale of cars to achieve the light-truck requirement. Percentages of various vehicle types assumed to be required un-

der the ZEV program are depicted in Figure 6, page 16 (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 Program" scenario based on the implementation scenario described above; and a "Global Warming Pollution Standards" scenario based on the percentage emission reductions proposed by the CARB staff in August 2004. Each scenario began with data from 2000 and continued through 2020.

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

## Other Assumptions

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

- **Rebound effects** – Research has shown that improved vehicle fuel efficiency often results in an increase in vehicle-miles traveled. By reducing the marginal cost of driving, efforts to improve efficiency provide an economic incentive for additional vehicle travel. Studies have found that this "rebound effect" may reduce the carbon dioxide emission savings of fuel economy-improving policies by as much as 20 to 30 percent.<sup>51</sup> To account for this effect, carbon dioxide reductions in each of the scenarios were discounted by 10 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.<sup>52</sup>

- **Mix shifting** – We assumed that neither of the policies under study would result in changes in the class of vehicles purchased by Arizona residents, or the relative amount that they are driven (rebound effect excluded). In addition, we assumed that the vehicle age distributions assumed by EPA remain constant under each of the policies. In

other words, we assumed that any increase in vehicle prices brought about by the global warming emission standards would not dissuade consumers from purchasing new vehicles or encourage them to purchase light trucks when they would otherwise purchase cars (or vice versa). Mix shifting impacts such as these are quite complex and modeling them was beyond the scope of this report, but they do have the potential to make a significant impact on future carbon dioxide emissions.

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3. See note 1.
4. See note 2.
5. U.S. Environmental Protection Agency, Office of Policy, Planning, and Evaluation, *Climate Change and Arizona*, September 1998.
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18. Governor Janet Napolitano, *Executive Order 2005-02: Climate Change Advisory Group*, 2 February 2005.
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22. Projected miles based on projected VMT for 2025 from Cambridge Systematics, Inc., for Arizona Department of Transportation, *MoveAZ Plan: Long-Range Transportation Plan*, September 2004.
23. See note 21.
24. Stacy C. Davis, Susan W. Deigel, Center for Transportation Analysis, Oak Ridge National Laboratory, *Transportation Energy Data Book: Edition 22*, September 2002, Chapter 7. The federal government is implementing a slight increase in light truck CAFE standards to take full effect for the 2007 model year.
25. U.S. Environmental Protection Agency, *Light-Duty Automotive Technology and Fuel Economy Trends: 1975 Through 2004*, Appendix C, April 2004. The federal law that established CAFE standards also established the means for testing of vehicles to determine compliance with the standards. It has long been recognized that these testing methods overstate the "real world" fuel economy of vehicles. EPA has begun to include adjusted figures in its reporting of fuel economy trends and, in its 2004 report, included an estimate of real-world vehicle mileage based on increases in the percentage of urban driving. In this report, all discussions of vehicle fuel economy will refer to "real world" efficiency levels rather than "EPA rated" levels.
26. U.S. Environmental Protection Agency, *Light-Duty Automotive Technology and Fuel Economy Trends: 1975 Through 2004*, Appendix C, April 2004.
27. Real world fuel economy: U.S. Environmental Protection Agency, *Light-Duty Automotive Technology and Fuel Economy Trends: 1975 Through 2004*, Appendix C, April 2004. CAFE standards: U.S. Department of Transportation, *Summary of Fuel Economy Performance*, March 2003.
28. See note 26.
29. Ibid.
30. U.S. Environmental Protection Agency, *Fleet Characterization Data for MOBILE6: Develop-*

ment and Use of Age Distributions, Average Annual Mileage Accumulation Rates, and Projected Vehicle Counts for Use in MOBILE6, September 2001; MOBILE6 run conducted by MASSPIRG Education Fund based on national defaults, January 2003.

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

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