A Blueprint for Action

Policy Options to Reduce Arizona's Contribution to Global Warming

Arizona PIRG Education Fund

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Executive Summary

Arizona could make major strides towards reducing its emissions of global warming pollution by adopting a set of policies to reduce the use of fossil fuels, to promote more efficient use of energy and to increase the use of cleaner renewable forms of energy.

Adoption of the 14 policy strategies in this report would help Arizona stabilize its emissions despite significant population growth. In the process, these strategies would improve Arizona's energy security and begin the technological shifts necessary to reduce Arizona's emissions of global warming pollution to levels that do not have a harmful effect on the climate.

Even with these strategies, however, Arizona will still need to take additional and immediate steps to reduce its contribution to global warming. We include suggestions for a variety of other policies that Arizona could investigate for further cuts in emissions.

Global warming, caused by human-induced changes to the climate, is a major threat to Arizona's future.

- Since the beginning of the Industrial Age, atmospheric concentrations of carbon dioxide—the leading global warming gas—have increased by 35 percent, a rate of increase unprecedented in the last 20,000 years. Global average temperatures increased by about 1° F during the 20th century, a greater rate of increase than at any time in the last 1,000 years.

- In Arizona, a changed climate is anticipated to include a wide variety of impacts.
  - o Global warming will exacerbate Arizona's existing water supply shortages. Smaller mountain snowpacks will reduce the amount of water in the Colorado River. Increased temperatures will induce more evaporation and reduce the amount of moisture in the soil, reducing groundwater recharge—the source of 60 percent of the state's drinking water.
  - o Heat waves and extreme high-temperature days in the summer will increase, resulting in an increased risk of heat-related illness and death.
  - o Greater winter precipitation will increase plant growth in the spring,

providing more fuel for wildfires during hotter and drier summers.

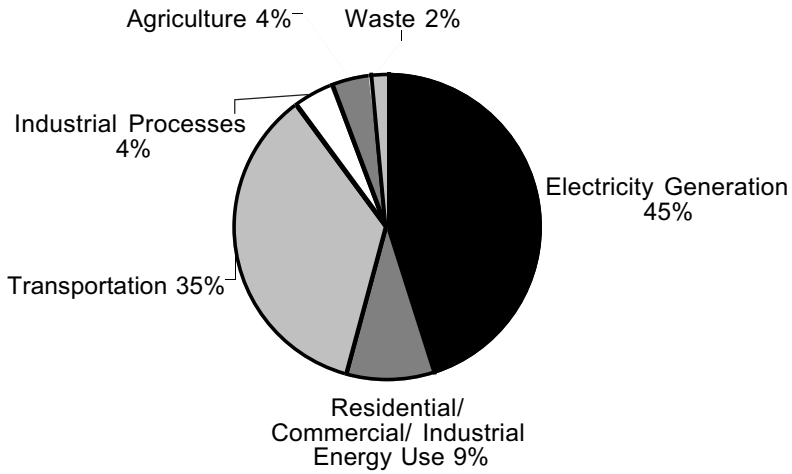
- The number of farmed acres could decline by 20 percent as crop yields fall.
- Greater year-to-year variation in precipitation could also lead to increases in rodent-borne diseases, such as hantavirus pulmonary syndrome.

Emissions of global warming pollution are on the rise in Arizona.

- Between 1990 and 2000, Arizona's emissions of carbon dioxide from energy use increased by 48 percent. Electricity generation (45 percent) is the largest source of global warming pollution, followed by transportation (35 percent). In addition to being major consumers of electricity, homes, businesses and industry contribute another 9 percent of emissions through their use of natural gas and other fuels. (See Figure ES-1.)
- Arizona is on a path that will lead to dramatic increases in global warming emissions over the next several decades. According to U.S. Energy Information Administration (EIA) projections of energy consumption growth and projections of Arizona's population growth, Arizona's emissions of carbon dioxide in 2025 could be more than twice as great as levels in 2000. We use this as our reference case.

Arizona could reduce its contribution to global warming by adopting 14 key policies and encouraging other states in the region to do the same. There are numerous tools available to Arizona to reduce global warming pollution. The following 14 strategies include policies that take advantage of readily available savings at low cost, or even net economic benefit, to Arizona.

Figure ES-1. Arizona Global Warming Pollution by Sector, 2000



Note: This figure includes emissions from all electricity generated in Arizona. Some power generated here is exported for consumption in other states.

To reduce emissions from transportation:

1. Adopt the **clean cars program**, which will put increasing numbers of hybrid-electric cars on Arizona's roads and impose limits on vehicle carbon dioxide emissions**.**
2. Require the sale of **low-rolling resistance replacement tires** that improve vehicle efficiency without negatively affecting safety.
3. Establish a revenue-neutral **"feebate"** program to reward the purchase of more fuel-efficient vehicles.
4. Require automobile insurers to offer **pay-as-you-drive automobile insurance,** in which insurance rates are calculated by the mile, rewarding those who drive less, while potentially reducing accidents.
5. Adopt policies that would **reduce growth in vehicle miles traveled** by cars and light trucks on Arizona's highways, such as measures to reduce sprawling development and encourage the use of transit and other transportation alternatives.
6. Establish a **renewable fuels standard**, so that a portion of motor fuel, both gasoline and diesel, comes from renewable sources.

To reduce emissions from homes, businesses and industry:

7. Reduce energy use by expanding **energy efficiency programs** supported by electricity and natural gas ratepayers.
8. Expand **appliance efficiency standards** for a series of residential and commercial products, saving money for consumers and reducing electric sector emissions.
9. Improve the efficiency of new **commercial and residential buildings** and thereby reduce building-related energy costs and global warming pollution.
10. Expand the use of energy-efficient **combined heat and power systems** in industry and commercial buildings.

To reduce emissions from electricity generation:

11. Dramatically increase the installation of **solar photovoltaic and thermal energy systems** on homes and businesses through direct incentives and new methods of financing.
12. Expand and strengthen the state's proposed **Renewable Energy Standard** so that 30 percent of all electricity consumed in Arizona comes from new, clean, renewable sources.
13. Stop the growth in emissions from **coal-fired power plants**, using appropriate public policy tools such as greater energy efficiency measures or a carbon "cap and trade" program.

To reduce emissions with other strategies:

14. Reduce **government sector emissions** through "lead by example" measures, such as by purchasing renewable power, cutting energy consumption in new buildings in half, increasing energy efficiency, and purchasing more efficient vehicles for state fleets.

Adoption of the 14 strategies presented in this report would reduce Arizona's emissions by approximately 77 million metric tons (MMT) of carbon dioxide below the reference case projected level by 2025, despite an expected 86 percent increase in population. (See Figure ES-2.) With just these 14 policies out of the many available, projected growth in carbon dioxide emissions would be near zero.

Table ES-1. Projected Annual Carbon Dioxide Emissions Reductions from 14 Strategies Quantified in this Report (measured in million metric tons of carbon dioxide)

Policy	2015	2020	2025
Clean Cars Program	2.3	4.7	7.2
Low-Rolling Resistance Replacement Tires	0.6	0.7	0.9
Feebate Program (AZ only)*	0.1	0.1	0.1
Pay-As-You-Drive Automobile Insurance	2.5	2.8	3.2
Reduce Growth in Vehicle Miles Traveled	4.4	7.3	10.7
Renewable Fuels Standard	2.0	3.1	4.9
Expanded Energy Efficiency Programs	3.9	6.4	9.1
Appliance Efficiency Standards	0.6	1.0	1.1
Residential and Commercial Building Codes	2.6	5.0	7.9
Combined Heat and Power	3.8	5.0	4.8
Solar Power Development	0.1	0.2	0.7
Expanded Renewable Energy Standard	8.2	13.4	18.9
Prevent Expansion of Coal-Fired Power Plants	10.1	27.8	47.6
Public Sector Lead By Example	1.5	2.2	3.0
Total	**26.6**	**51.3**	**77.2**

** Savings are likely to be greater from a feebate program that includes multiple states.*
Note: Savings from individual policies do not equal cumulative savings due to some overlap between the policies.

Adoption of additional strategies—such as the several dozen other policies being considered by the Climate Change Advisory Group—can reduce emissions further and produce a reduction in total global warming emissions, not just a reduction in the emissions growth rate.

Masked in the cumulative emission projections presented in Figure ES-2 are diverging trends in the savings achieved in the electricity generation sector and in the transportation, residential, commercial and industrial sectors. The strategies presented in this report would cause electric sector emissions to decline each year (see Figure ES-3), while other emissions continue to rise.

By using existing technologies and reasonable public policy tools, Arizona can make large strides toward reducing the state's contribution to global warming in the near term, while in many cases improving public health, economic well-being and energy security. To reap these benefits, Arizona must seize every opportunity to begin reducing its emissions.

- Arizona should adopt strong goals for reducing global warming pollution to provide clear benchmarks against which to measure its progress. For example, New Mexico intends to reduce its pollution by 10 percent below 2000 levels by 2020 and California has announced it will reduce emissions to 1990 levels by 2020.
- Arizona should promptly adopt the measures in this report and investigate other policy options to reduce global warming emissions, especially with regards to reducing vehicle-miles

traveled and encouraging the development of non-fossil, non-nuclear sources of energy.

- Arizona should begin to plan for the technological and other changes that will be needed to achieve the long-term goal of reducing global warming emissions to a level that will not threaten the climate.

Figure ES-2. Arizona's Carbon Dioxide Emissions after Adoption of 14 Strategies Quantified in this Report

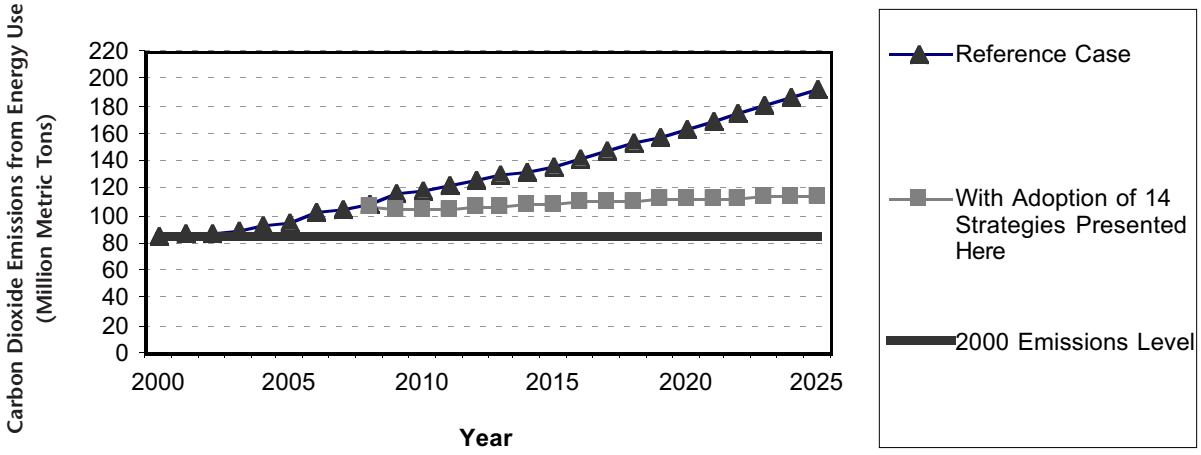
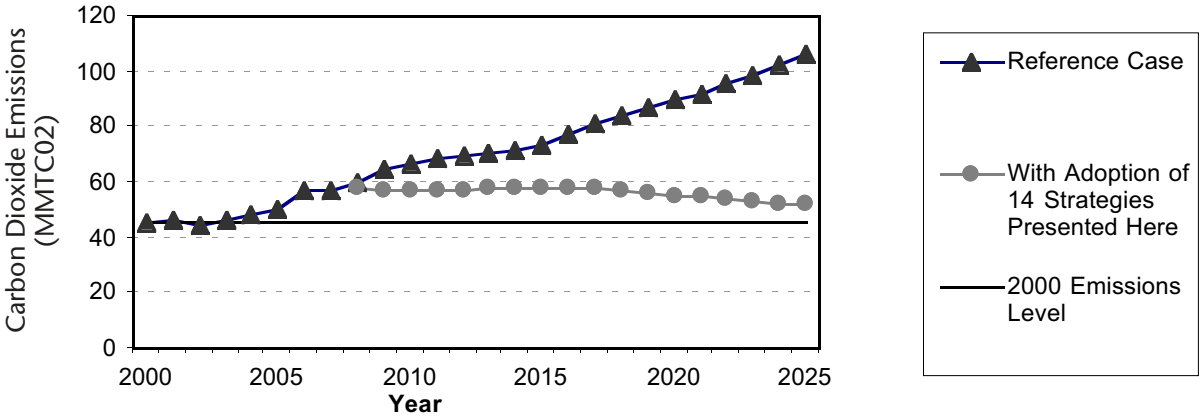


Figure ES-3. Arizona's Electric Sector Carbon Dioxide Emissions after Adoption of 14 Strategies Quantified in this Report



Introduction

The consensus view of climate science holds that global temperatures are increasing, that human activities are the cause, and that further warming of the planet is inevitable unless we significantly reduce emissions of gases that trap heat in the Earth's atmosphere.

Global warming will produce climatic shifts that will change the Arizona landscape and way of life. Arid deserts, snowmelt-fed rivers, pasture lands and weather patterns will all be far different from what we have known.

Recognizing this, in February 2005, Governor Janet Napolitano issued an executive order creating the Arizona Climate Change Advisory Group. The group is charged with providing recommendations regarding climate change policy.[1] Working with New Mexico Governor Bill Richardson, she also recently created the Southwest Climate Change Initiative to craft joint strategies for reducing global warming pollution.[2] Unlike New Mexico and California, which are striving to reduce global warming pollution well below 2000 levels by 2020, Arizona has not yet established specific targets for reducing emissions, but the Climate Change Advisory Group is expected to do so soon.

Reducing global warming pollution will not be easy. Arizona's population is projected to increase by 86 percent from 2000 to 2025. As a result of this and other factors, the state's global warming pollution is expected to more than double.

At the same time, this projected population growth offers an opportunity for Arizona to dramatically rethink how it uses energy. Hundreds of thousands of new homes will be built to accommodate new residents. Those homes could be constructed to meet the highest efficiency standards, reducing energy use and global warming pollution, as well as saving money for homeowners. New communities can be designed to allow people to walk, bike or ride transit instead of driving, a change that will reduce global warming emissions.

Further, the state has greater solar resources than most areas of the country. Every new home could include rooftop solar panels that generate emission-free electricity to meet the needs of that home. Any excess electricity could be sold back into the power grid, replacing energy generated by high-emission coal-fired power plants.

Global warming emissions from existing sources can be reduced as well. New automobiles can be constructed to use energy

more efficiently. Buildings can be retrofitted to use less energy and thereby release less global warming pollution. Other renewable energy sources such as biofuels and wind power are increasingly cost-competitive with traditional fossil fuel sources of energy.

The state can reduce its global warming pollution, but only if it finds the will to do so—creating programs to cut emissions and implementing these programs to achieve the greatest emission savings. Arizona must act aggressively and early to curb greenhouse gases. Investing now in our growing infrastructure can make enormous differences down the road.

This report presents 14 policy opportunities and estimates how implementation of these policies will affect Arizona's emissions of carbon dioxide—the leading global warming pollutant. The policy options explored in detail here would, if implemented, allow Arizona to essentially stabilize its emissions in the near term. But this is only a beginning. The state must pursue additional policies that will reduce its emissions, not just stabilize them.

These actions—if taken—will move Arizona towards the cleaner, more efficient, more sustainable and healthier future that we all deserve.

Global Warming and Arizona

Global warming poses a clear danger to Arizona's future health, well-being and prosperity. Arizona contributes to global warming primarily through the combustion of fossil fuels, which emit carbon dioxide into the atmosphere. Arizona's emissions of carbon dioxide and other global warming gases have increased dramatically over the last decade and will continue to increase in the absence of concerted action.

Causes of Global Warming

Global warming is caused by human exacerbation of the greenhouse effect. The greenhouse effect is a natural phenomenon in which gases in the earth's atmosphere, including water vapor and carbon dioxide, trap heat from the sun near the planet's surface. The greenhouse effect is necessary for the survival of life; without it, temperatures on earth would be too cold for humans and other life forms to survive.

However, human activities, particularly over the last century, have altered the composition of the atmosphere in ways that intensify the greenhouse effect by trapping more of the sun's heat near the earth's surface. Since 1750, for example, the concentration of carbon dioxide in the atmosphere has increased by 35 percent as a result of human activity.[3] The current rate of increase in carbon dioxide concentration is unprecedented in the last 20,000 years.[4] Concentrations of other global warming gases have increased as well. (See Figure 1.)

As the composition of the atmosphere has changed, global temperatures have increased. Global average temperatures increased during the 20th century by about 1° F. In the context of the past 1,000 years, this amount of temperature change is unprecedented, with 1990 to 2000 being the warmest decade in the millennium.[6] Figure 2 shows temperature trends in the Northern Hemisphere for the past 1,000 years with a relatively recent upward spike. Temperatures in the past 150 years have been measured; earlier temperatures are derived from proxy measures such as tree rings, corals, and ice cores.

This warming trend cannot be explained by natural variables—such as solar cycles or volcanic eruptions—but it does correspond

Figure 1. Atmospheric Concentrations of Greenhouse Gases[5]

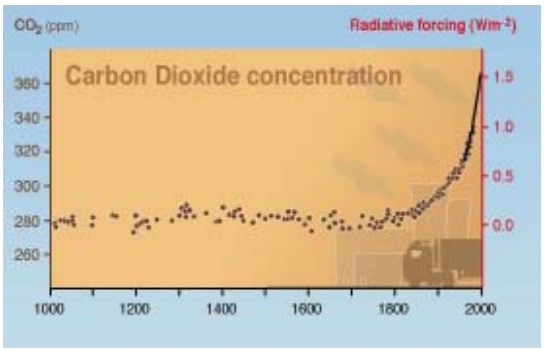
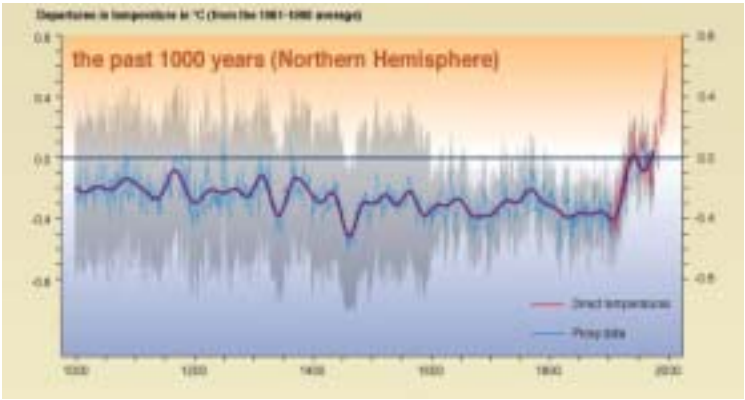


Figure 2. Northern Hemisphere Temperature Trends[7]



to models of climate change based on human influence.[8]

Current Indications of Global Warming

The first signs of global warming are beginning to appear, both in Arizona and around the world.

Average temperatures have risen. Global average temperatures have increased by 1° F in the past century.[10] In the same period, an overall increase in the average annual temperature of 2° F to 3° F has been detected in the southwestern U.S.[11] In the Colorado River basin, which includes all of Arizona, the average temperature in the last five years has been hotter than at any time in more than a century.[12]

Precipitation patterns have changed. Many parts of Arizona have experienced increases in precipitation of up to 20 percent, with the exception of northwestern Arizona, where precipitation has declined by 20 percent.[13] In Arizona and throughout the western U.S., rising temperatures have led to a decrease in winter snowfall and an increase in winter rainfall.[14] This results in smaller snowpacks, which are important for drinking water supplies. Snowpack in the Colorado River basin has been below average in 11 of the last 16 years.[15]

Cold seasons have been shorter and extreme low temperatures less frequent. Mountain glaciers around the world have been retreating, and since the late 1960s, Northern Hemisphere snow cover has decreased by 10 percent.[16]

Other Global Warming Pollutants

In addition to carbon dioxide, several other pollutants are capable of exacerbating the greenhouse effect that causes global warming.[9] The other major global warming pollutants are:

- **Black Carbon** – Black carbon, otherwise known as "soot," is a product of the burning of fossil fuels, particularly coal and diesel fuel. Recent research has suggested that, because black carbon absorbs sunlight in the atmosphere, it may be a major contributor to global warming, perhaps second in importance only to carbon dioxide. Research is continuing on the degree to which black carbon emissions contribute to global warming.
- **Fluorocarbons** – Used in refrigeration and other products, many fluorocarbons are capable of inducing strong heat-trapping effects when they are released into the atmosphere. However, because they are generally emitted in small quantities, fluorocarbons are responsible for only a tiny fraction of Arizona's total contribution to global warming.
- **Methane** – Methane gas escapes from garbage landfills, is released during the extraction of fossil fuels, and is emitted by livestock and some agricultural practices. Methane represents a relatively small portion of Arizona's global warming emissions, but it is one of the most important global warming gases in terms of its potential to exacerbate the greenhouse effect.
- **Nitrous Oxide** – Nitrous oxide is released in automobile exhaust, through the use of nitrogen fertilizers, and from human and animal waste. Like fluorocarbons, nitrous oxide is a minor, yet significant, contributor to global warming.
- **Sulfur Hexafluoride** – Sulfur hexafluoride is mainly used as an insulator for electrical transmissions and distribution equipment. It is an extremely powerful global warming gas, with more than 20,000 times the heat-trapping potential of carbon dioxide. However, it is released only in very small quantities and is responsible for only a very small portion of the state's contribution to global warming.

This report focuses mainly on emissions of carbon dioxide from energy use, since these emissions are responsible for the majority of Arizona's contribution to global warming. Steps to reduce emissions of other global warming gases and carbon dioxide from activities other than energy use should also be part of the state's efforts to curb global climate change.

Mountain snowpack is now melting earlier in the year. The average timing of peak flows in most of the 270 snowmelt-dominated western rivers and streams occurs 10 to 30 days earlier than peak flow 50 years ago.[17]

Storms throughout the middle and high latitudes of the Northern Hemisphere have been getting more intense. The increase in the frequency of heavy precipitation events arises from a number of causes, including changes in atmospheric moisture, thunderstorm activity and large-scale storm activity.[18]

Oceans have risen with the melting of glacial ice and the expansion of the ocean as it warms. Average sea levels have risen 0.1 to 0.2 meters in the past century.[19]

Potential Impacts of Global Warming

The earth's climate system is extraordinarily complex, making the ultimate impacts of global warming in a particular location—as well as the pace of change—difficult to predict. There is little doubt, however, that global warming could lead to dramatic disruptions around the world and to Arizona's economy, environment, health and way of life.

Temperature increases in the past century have been modest compared to the increases projected for the next 100 years. Should global warming pollution continue to rise, the U.S. Global Change Research Program projects that average temperatures in the Southwest could increase 4° F to 7° F by 2090.[20] At the global scale, the Intergovernmental Panel on Climate Change (representing the world scientific consensus on global warming) forecasts that average temperatures could rise 2.5° F to 10° F between 1990 and 2100.[21]

Average precipitation levels also could change. Over the next 100 years Arizona could experience up to a 15 percent decrease in summer rainfall and experience an increase in precipitation during the rest of the year of up to 60 percent—with the greatest change expected in the winter.[22] Days with very heavy rain or snowfall could increase.

An important part of the Southwest's climate change scenario is increased year-to-year variability in rainfall.[23] This regional trend is expected to be replicated around the globe—indeed, scientists predict that large year-to-year variations in precipitation are very likely over most land areas where an increase in average precipitation is projected.[24]

Although global warming is likely to increase average annual precipitation in Arizona, this may not translate into an increase in the amount of water available for ranching, farming, and urban use. Higher average temperatures are expected to increase evaporative water loss.

Current global warming trends could have substantial impacts on Arizona's economy, environment and quality of life—both for future generations and for children growing up in Arizona today. Among the projected impacts:

- The Colorado River will be less able to supply water for Arizona. Since snowmelt provides more than 70 percent of the water in the Colorado River, declining snow levels will have a serious impact on how much water the river can deliver to communities across the Southwest.[25] Using a climate model developed by the National Center for Atmospheric Research, scientists have projected that 30 percent of the Colorado River snowpack could be gone in roughly the next 50 years.[26] Given the rapid growth of states like Arizona, Nevada and Utah, the scientists concluded that the water allocation system in the region is "on the brink of failure."[27] (See "Global Warming and Water Supply for Arizona" on page 15.)
- Smaller snowpack will also reduce groundwater supplies. Scientists have determined that in the Rocky Mountain West, snowmelt recharges

groundwater supplies more effectively than does rain. Thus, a decrease in snowmelt will lead to a decrease in groundwater and—as groundwater currently supplies 60 percent of Arizona's drinking water needs—this could exacerbate existing water shortages.[28]

- The frequency of heat waves and extreme high-temperature days in the summer could increase, resulting in an increased risk of heat-related illness and death.[29]
- The risk of wildfires in the state could grow. Increased winter precipitation will increase plant productivity in the spring, which will create more fuel for potential wildfires during the hotter and drier summer months.[30]
- More rapid snowmelt will contribute to increased winter and spring flooding, and more intense summer storms could increase the likelihood of flash floods. Increased flooding will lead to greater erosion, exacerbate levels of pesticide and fertilizer contamination in runoff from agricultural lands, and increase risks of overflow from storage reservoirs and holding ponds containing contaminants from mining operations.[31]
- The U.S. Environmental Protection Agency estimates that global warming could reduce the number of farmed acres in Arizona by up to 20 percent. Rising temperatures could lead to decreased crop production; yields of wheat (a heat-sensitive grain) could fall by 70 percent.[32]
- As a majority of ranchland in Arizona is not irrigated, increased winter rain could increase rangeland carrying capacity. However, as the climate change scenarios also include increased year-to-year variability in precipitation—and variability in precipitation can directly affect the availability of grazing material—the region's ranchers will be placed in a more precarious and vulnerable position.[33]
- Greater year-to-year variation in precipitation could also lead to

Global Warming and Water Supply in Arizona

Global warming could reduce the availability of water for cities, towns and farms across Arizona, with serious implications for population growth and the regional economy.

Researchers are concerned that global warming could aggravate the effects of drought by inducing more evaporation and reducing the amount of moisture in the soil—limiting aquifer recharge and extending the wildfire season.[35]

Arizona is already experiencing the effects of a long-term drought. In February 2006, Tucson had to activate water wells normally reserved for high-demand summer months, because rain had not fallen for 60 days.[36] Williams, a town outside Flagstaff, was recently forced to drill wells more than 3,000 feet deep to find enough water.[37] In 2002, the drought cost cattle ranchers and related industries $2.8 billion.[38]

In addition, lower snowpack levels could make the Colorado River less reliable.[39] States along the Colorado River are already legally entitled to more water than actually exists in the river.[40] Since Arizona holds the least-protected rights to river water, serious water shortages are likely this century.[41]

increases in rodent-borne diseases, such as hantavirus pulmonary syndrome. Long droughts punctuated by heavy rain can reduce populations of rodent predators (owls, snakes and coyotes) and bring about a boom in rodent populations.[34]

- Hotter summers will result more severe smog seasons as high temperatures facilitate the formation of ground level ozone, resulting in increased threats to respiratory health.

Global warming-induced changes predicted by the latest scientific research will have a dramatic, disruptive effect on Arizona's environment, economy and public health. Avoiding these impacts will require immediate action to limit our emissions of global warming pollution.

Global Warming Pollution Trends

Background on this Analysis

In this document, we use data and projected regional trends compiled by the U.S. Energy Information Administration to develop a baseline projection of energy-related carbon dioxide emissions in Arizona (called the "reference case") and to estimate the benefits of various policies to reduce carbon dioxide emissions.

We examine only emissions of carbon dioxide (and not emissions of the other gases that contribute to global warming). (See Figure 3.) The omission of other global warming pollutants from other sources is a result of time and resource constraints and is not intended to minimize the importance of reducing these emissions in Arizona.

We generally do not factor in the impact of various policies on "upstream" emissions—for example, the emissions that result from the production of gasoline that is later used in cars and trucks. And we assume that any reduction in electricity consumption in Arizona will result in a proportional reduction in electricity production within the state.

For a detailed description of the methodology used in this report, see "Methodology and Technical Discussion" at the end of this report.

Global Warming Pollution on the Rise

Fossil fuels are burned directly in homes, businesses, vehicles and industrial facilities to produce heat and to power machinery. Individuals and businesses also consume fossil fuels indirectly when they use electricity, much of which is created through the combustion of coal and natural gas in power plants.

The reference case scenario created for this document is based on "business as usual" energy consumption projected by the U.S. Energy Information Administration for the Mountain Region, adjusted for Arizona's higher population growth relative to the rest of the region. The reference case projects a significant increase in global warming pollution over the next decade and a half. Arizona's emissions of carbon dioxide from energy use can be expected to increase by approximately 110 percent between 2000 and 2025.

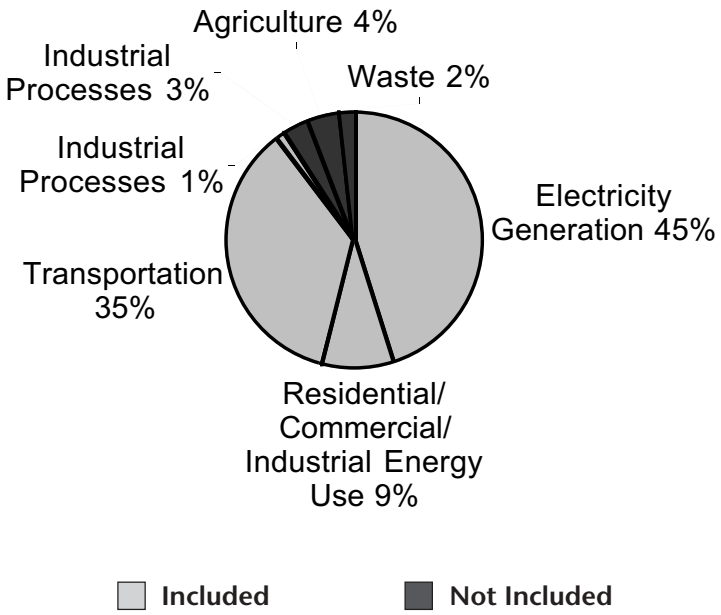
While projections of the degree of increase in global warming pollution in Arizona may differ, one thing is for certain: Arizona faces a future of dramatically increasing emissions of global warming gases unless immediate and strong action is taken to reverse the trend.

Arizona's Direct (Non-Electric) Emissions

Arizonans contribute to the release of carbon dioxide in three ways:

- **Directly**, through the burning of fossil fuels in homes, businesses and vehicles.

Figure 3. Arizona Global Warming Pollution Included and Not Included in this Analysis, 2000[42]

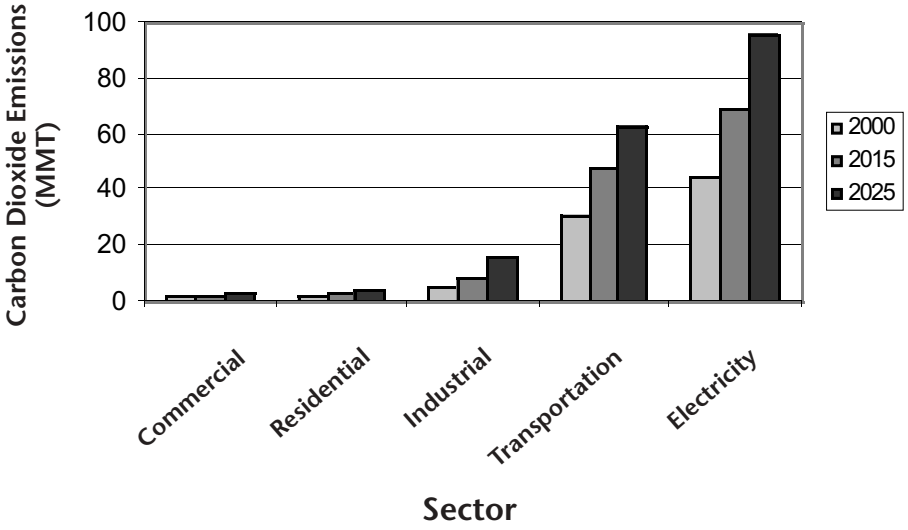


A Note on Units

There are several ways to communicate quantities of global warming emissions. To be consistent with other recently published studies on global warming emissions in Arizona, we communicate emissions in terms of "carbon dioxide equivalent"—in other words the amount of carbon dioxide that would be required to create a similar global warming effect. A million metric tons of carbon dioxide equivalent is expressed as $MMTCO_2e$. Other studies frequently communicate emissions in terms of "carbon equivalent." A million metric tons of carbon equivalent is expressed as MMTCE. To translate carbon equivalent to carbon dioxide equivalent so that results from different studies can be compared, one can simply multiply by 3.667, the result of the different molecular weights of carbon dioxide versus carbon.

One metric ton of carbon dioxide is equal to the amount of carbon dioxide released by the typical passenger car after being driven 2,400 miles. One million metric tons is the amount of carbon dioxide released by 192,000 cars in a year.[43]

Figure 4. Projected Carbon Dioxide Emissions by Sector, Arizona



- **Indirectly**, through the consumption of electricity produced from fossil fuels.
- Through **upstream pollution** created in the production of products and energy that Arizonans use. (For example, pollution produced during manufacture of a car.) Since upstream pollution is difficult to quantify and much of it takes place outside of Arizona, it is not included in this report.

Between 1990 and 2000, Arizona's direct emissions (emissions from sources other than fuel burned for electricity generation) of carbon dioxide—the leading global warming gas—increased by approximately 47 percent. In 2000, the transportation sector was responsible for the largest share of Arizona's direct carbon dioxide emissions. The industrial, commercial and residential sectors were responsible for about 22 percent of direct emissions, as well as the bulk of the electricity consumed in the state.[44]

Overall, direct carbon dioxide emissions in our baseline scenario are projected to increase by 53 percent over 2000 levels by 2015 and by 112 percent over 2000 levels by 2025.

The largest gross increase in direct carbon dioxide emissions is projected to occur in the transportation sector—with transportation emissions of carbon dioxide growing from 31.4 to 63.3 $MMTCO_2$, a 102 percent increase from 2000 to 2025 in the reference case. The fastest percentage increase is projected to occur in the industrial sector, with carbon dioxide emissions tripling.[45] (See Figure 4.)

Electric Sector Emissions

Arizona's power plants are the largest source of global warming emissions in the state. Energy produced by these power plants is used predominantly by the residential, commercial, and industrial sectors and some is exported. This electricity is used to light buildings, run fans and cooling systems, power appliances, and operate many types of industrial machinery. Arizona's power plants have historically produced more electricity than is consumed in the state, making Arizona an important exporter of electricity to the rest of the

region. In 2000, for example, Arizona produced 23 percent more electricity than needed for in-state use.[46] The figures used in this report include all electricity generated in Arizona, not simply electricity consumed in the state.

Between 1990 and 2000, Arizona's electric sector carbon dioxide emissions increased from 32.8 to 45.1 MMTCO2, an increase of 37 percent. However, the EIA's projected future trends in energy consumption in the Mountain Region—of which Arizona is part—suggest that emissions from electric generation in Arizona could increase even more rapidly over the next 25 years. Indeed, assuming that Arizona continues in its role as a net power exporter, the state could be expected to experience a 54 percent increase in carbon dioxide emissions over 2000 levels by 2015 and a 112 percent increase over 2000 levels by 2025.[47]

Global Warming Strategies for Arizona

Reducing Emissions from the Transportation Sector

The transportation sector poses a serious challenge for Arizona as the state seeks to reduce its emissions of global warming pollution. Transportation is Arizona's second-largest source of carbon dioxide emissions—responsible for more than one-third of the state's emissions in 2000. If current trends towards increasing vehicle travel continue, transportation-sector global warming emissions in Arizona are likely to increase by 102 percent between 2000 and 2025.

Light-duty vehicles are the largest source of transportation-sector carbon dioxide emissions, responsible for about two-thirds of transportation emissions in Arizona.[48] Any strategy to deal with transportation's contribution to global warming, therefore, must begin with addressing emissions from cars, light trucks, and SUVs.

Achieving reductions in transportation emissions will require swift action. Many of the transportation-sector strategies have a long lead time before they begin to produce significant savings due to the fact that they primarily affect new vehicle purchases. Once sold, new vehicles typically remain on the road for 10 to 15 years or more. Thus, any delay in adoption of these measures will result in more high-carbon vehicles traveling Arizona's roadways for years to come.

There are three ways to reduce emissions from motor vehicles: improve fuel economy, switch to low-carbon fuels, or reduce vehicle travel. To achieve meaningful reductions, the state will have to make progress in all three areas. Adoption of a clean cars program would promote improved fuel economy and greater use of low-carbon fuels. Energy efficiency standards for tires and a vehicle efficiency incentive program (otherwise known as a "feebate" plan) would reduce gasoline consumption, while a state renewable fuels requirement would encourage the use of less carbon-intensive fuels. Finally, a concerted program to reduce the growth in vehicle travel would enhance the impact of all the other efforts, allowing Arizona to make substantial progress in reducing global warming emissions from transportation.

Strategy #1

Adopt the Clean Cars Program

Potential Savings: 2.26 MMTCO$_2$ by 2015; 7.25 MMTCO$_2$ by 2025.[49]

Arizona can adopt the "clean cars program" developed by the state of California and adopted by nine other states, which will require significant reductions in global warming emissions from vehicle tailpipes.[50]

The federal Clean Air Act allows states that fail to meet clean air health standards to choose between two sets of emission standards: those in place at the federal level and the traditionally tougher standards adopted by the state of California.

Over the last several decades, the "clean cars program" has evolved to include three elements:

- Low emission vehicle standards that require reductions in smog- and soot-forming pollutants.
- Advanced technology vehicle standards that spur the introduction of low-polluting, high-technology vehicles into the fleet, such as near-zero emission gasoline cars, hybrid-electric vehicles, and eventually hydrogen fuel-cell vehicles.
- Tailpipe emission standards for global warming pollution.

Of the three components of the clean cars program, the advanced technology standards and tailpipe emission standards for global warming pollution have the greatest potential to reduce global warming pollution from Arizona's transportation sector.

Advanced Technology Standards

While primarily a program for reducing smog-forming and toxic emissions from automobiles, the clean cars program's "technology forcing" component will likely reduce carbon dioxide emissions by requiring the introduction of significant numbers of advanced technology vehicles (including hybrid-electric vehicles) and, eventually, hydrogen fuel-cell vehicles. Beginning in 2010 (which is when 2011 model year cars will go on sale), automakers would be required to sell the equivalent of more than 10,000 hybrid vehicles per year in Arizona, with the numbers increasing over time. Then, beginning in 2011, automakers would be required to sell small numbers of hydrogen fuel-cell vehicles—again, with the numbers increasing over time. By 2020, about 9 percent of new light-duty vehicles sold in Arizona would be hybrids, while about 1 percent would be hydrogen fuel-cell or other vehicles with zero emissions.[51]

Hybrid-electric vehicles have already proved popular with drivers in Arizona and elsewhere. Sales of hybrid-electric vehicles have increased steadily since their introduction to the domestic market in December 1999. About 210,000 hybrids were sold in the U.S. in 2005, 2.5 times as many as in the previous year.[52]

The future of hydrogen fuel-cell vehicles is less certain. Fuel cells use a chemical reaction involving hydrogen to produce electricity, which is then used to power a vehicle. When pure hydrogen is used in a fuel cell, the only byproduct is water and heat.

A limited number of fuel cell vehicles are currently on the road in demonstration projects. And while most major automakers have stated that they are committed to developing fuel cell vehicles, none have thus far committed to a firm timeline for introduction. Significant technological and market hurdles remain in the way of an effective system for generating, storing and distributing pure hydrogen. Even if pure hydrogen can be used as a fuel, the possibility exists that polluting and dangerous fuels such as coal and nuclear power could be used to generate the hydrogen, creating new environmental and public health threats. Thus, renewable sources of hydrogen are central to a fuel cell future that delivers dramatic reductions in global warming pollution.

Despite these potential problems, fuel

cells are inherently more efficient than traditional internal combustion engines and, ideally, could become an emission-free form of transportation. Similarly, battery-electric vehicles could help fulfill the requirements for vehicles with no direct pollutant emissions. Other technologies, such as natural gas and other clean alternative-fuel vehicles, are advancing as well and could be used to meet program requirements.

In its Greenhouse Gases, Regulated Emissions and Energy Use in Transportation (GREET) model, the Argonne National Laboratory estimated that hybrid-electric passenger cars release approximately 47 percent less carbon dioxide per mile than conventional vehicles. Fuel cell passenger cars operating on hydrogen derived from natural gas are projected to produce about 62 percent less carbon dioxide than conventional vehicles.[53] The requirements for these vehicles would likely produce a 1 to 2 percent reduction in global warming emissions from light-duty vehicles in Arizona.[54]

Global Warming Emission Standards

In 2002, the clean cars program was expanded with the addition of a law calling for carbon dioxide emission standards for motor vehicles. The Greenhouse Gas Emission Standards for Vehicles law was the first in the nation to regulate carbon dioxide from automobiles.

The legislation required the California Air Resources Board (CARB) to propose limits that "achieve the maximum feasible and cost effective reductions 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 could not be imposed to attain the new standards.[55] In September 2004, CARB adopted rules for implementation of the greenhouse gas emissions standards for vehicles.

In estimating the benefits of the global warming and vehicles standards, we assume that Arizona vehicles will achieve the same percentage emission reductions as estimated by CARB—34 percent for cars and 25 percent for light trucks by 2016.[56] CARB estimates that adoption of the standards would lead to net consumer benefits of $3 per month for new car purchasers and $7 per month for light-truck buyers, with the higher cost of vehicles being more than offset by reductions in operating costs, primarily the cost of fuel.[57]

Arizona can lay the groundwork for implementation of the global warming and vehicle standards by moving forward with full adoption of the clean cars program rules. Arizona should also encourage other states in the region to adopt the strongest available automobile emission standards. The emergence of a regional block of states in support of carbon dioxide emission standards will create leverage that can be used in securing stronger strategies to reduce automotive carbon emissions at the federal level.

Strategy #2

Set Standards Requiring Low-Rolling Resistance Replacement Tires

Potential Savings: 0.56 MMTCO$_2$ by 2015; 0.92 MMTCO$_2$ by 2025.

Fuel efficiency standards for replacement tires can improve the fuel economy of the existing vehicle fleet at a net savings to consumers.

Automobile manufacturers typically include gas-saving low-rolling resistance (LRR) tires on their new vehicles in order to meet federal corporate average fuel economy (CAFE) standards. However, LRR tires are generally not available to consumers as replacements when original tires have worn out. As a result, vehicles with replacement tires do not achieve the same fuel economy as vehicles with original tires.

The potential savings in fuel—and carbon dioxide emissions—are significant. A 2003 report conducted for the California Energy Commission found that LRR tires would improve the fuel economy of vehicles operating on replacement tires by about 3 percent, with the average driver replacing the tires on their vehicle when the vehicles reached four, seven and 11 years of age. The resulting fuel savings would pay off the additional costs of the tires in about one year, the report found, without compromising safety or tire longevity.[58]

Several potential approaches exist to encourage the sale and use of LRR tires—ranging from labeling campaigns (similar to the Energy Star program) to mandatory fuel efficiency standards for all light-duty tires sold in the state. California recently chose the latter approach, adopting legislation requiring that replacement tires sold to consumers beginning in July 2008 have the same average energy efficiency as the original tires provided by automakers.[59] The state will rate the energy efficiency of different tires based on testing information provided by manufacturers. The law does not require that each tire be labeled with its efficiency rating, but the information should be available to Arizona to develop similar requirements.

A standards program that required the sale of LRR tires beginning in 2008 in Arizona—assuming the same tire replacement schedule and per-vehicle emission reductions found in the California study—would ultimately reduce carbon dioxide emissions from the light-duty fleet by about 2 percent by 2025, while also providing a net financial benefit to consumers through reduced gasoline costs.

The Federal CAFE Preemption

The setting of federal corporate average fuel economy (CAFE) standards for cars and light trucks in 1975 was the most important policy move in U.S. history to improve the fuel economy of light-duty vehicles. As a result of CAFE standards, the miles-per-gallon fuel economy of cars and light trucks nearly doubled between the mid-1970s and the late 1980s.[60]

However, CAFE standards have remained largely stagnant over the last decade; standards for cars have not increased since 1990. Moreover, the federal law that created the standards also bars states from adopting regulations that are "related to fuel economy standards." The language of the law explicitly bars states from imposing fuel economy requirements on vehicles, but the use of the phrase "related to" also casts legal shadows on other measures—from efficiency-based fees and incentives to limits on carbon dioxide emissions from vehicles—that could be construed by some as "related to" fuel economy standards.

It is important to note the major role federal decision-makers can play in reducing carbon dioxide emissions from transportation. An increase in the federal CAFE standards to at least 40 MPG, applied to both cars and light trucks and phased in over time, would have a dramatic impact on carbon dioxide emissions. However, with the federal government resisting further significant increases in CAFE standards, it may be up to states such as Arizona to introduce other policies aimed at reducing transportation-sector carbon dioxide emissions.

Strategy #3

Implement a "Feebate" Program

Potential Savings: 0.08 MMTCO$_2$ by 2015; 0.14 MMTCO$_2$ by 2025.

The federal fuel economy preemption limits the number of policy tools available to states to reduce the fuel consumption—and resulting carbon dioxide emissions—of passenger vehicles. One potential tool to reduce the global warming impact of motor vehicles is a package of fees and rebates based on carbon dioxide emissions, commonly known as a "feebate."

A feebate program would give financial incentives to car buyers who purchase lower-emitting vehicles (which tend also to be more fuel-efficient) and fund those incentives through fees on purchasers of higher-emitting vehicles. Consumers who purchase vehicles at the mid-range of the emission scale—known as the "zero point"—would receive no rebate and pay no fee. The ideal zero point for a revenue neutral feebate program is usually thought to be the average per-mile carbon dioxide emission rate of all vehicles sold.

There are many potential variations of feebate programs. Feebates can apply equally across all vehicle classes, or can include separate zero points for cars and light trucks or for vehicle subclasses (e.g. subcompacts). Feebates can be structured to apply either to new vehicles or to both new and used vehicles. Feebate rates can be applied in a linear fashion—with rates increasing in direct proportion to carbon emissions—or be structured to specifically target vehicles in the middle of the efficiency spectrum. Finally, the rate of the feebate can vary, from a token charge to levels that generate maximum fees and rebates in the range of several thousand dollars.

Although no state currently has a feebate program in place, Maryland briefly adopted a program, but it was not implemented due to a legal dispute with the federal government over a separate labeling provision. Furthermore, several New England states are currently considering feebate programs—Rhode Island has engaged in detailed discussions of potential feebate scenarios as part of its Greenhouse Gas Stakeholders Process and Connecticut endorsed a feebate program in its stakeholder process.

The impact of a feebate program depends largely on how it is structured, but it also depends on the number of vehicles covered by the program. Several studies by researchers at the Lawrence Berkeley National Laboratory found that the majority of the improvement in fuel economy that would result from a feebate program would be generated by the response of manufacturers—rather than the response of individual consumers. These studies concluded that the manufacturers would make more fuel-efficient vehicles to respond to the economic signals of a feebate program, but that the manufacturers' response likely would be significantly less if only a small portion of the car and light-truck market were covered by a feebate program.[61]

A feebate program adopted solely in Arizona—which represents barely more than 2 percent of the total car and light truck market—would, therefore, have very limited results, since the aggregate buying power of the state's consumers would probably not be sufficient to force manufacturers to change the mix of vehicles they produce and sell.[62] However, adoption of a feebate in Arizona would set an important precedent for other states to follow. A regional program—implemented consistently across Arizona and other Western states—would not only bring a significantly greater likelihood of manufacturer response, but would also ease implementation of the program by reducing the possibility of escaping the feebate by purchasing or registering vehicles in neighboring states.

The estimated emission reduction in this report is based on an Arizona-only feebate. A feebate system that included multiple states, and that triggered a full response by the manufacturers, would likely have a far greater impact. In this alternate case, a

feebate would reduce transportation emissions in Arizona by approximately 1.0 $MMTCO_2$ in 2015 and 1.8 $MMTCO_2$ in 2025.

Strategy #4

Implement Pay-As-You-Drive Automobile Insurance

Potential Savings: 2.46 $MMTCO_2$ by 2015; 3.25 $MMTCO_2$ by 2025.

In a perfectly functioning market, the rates individuals pay for automobile insurance coverage would accurately reflect the risk they pose to themselves and others. Insurers currently use a host of measures—including vehicle model, driving record, location and personal characteristics—to estimate the financial risk incurred by drivers.

One measure that is strongly linked to automobile safety and yet is not used with any accuracy is travel mileage. Common sense and academic research suggest that drivers who log more miles behind the wheel are more likely to get in an accident than those whose vehicles rarely leave the driveway.[63] Many insurers do provide low-mileage discounts to drivers, but these discounts are often small, and do not vary based on small variations in mileage. For example, a discount for vehicles that are driven less than 7,500 miles per year does little to encourage those who drive significantly more or less than 7,500 miles per year to alter their driving behavior. As a result, the system fails to effectively encourage drivers to reduce their risk by driving less.

Requiring automobile insurers to offer mileage-based insurance is just one of many potential policies that attempt to reallocate the upfront costs of driving. High initial cost barriers to vehicle ownership—such as insurance, registration fees and sales taxes—may reduce driving somewhat by denying vehicles to those who cannot afford these costs. But for the bulk of the population that can afford (or has little choice but to afford) to own a vehicle, these high initial costs serve as an incentive to maximize the vehicle's use. Per-mile charges operate in the opposite fashion, providing a powerful price signal for vehicle owners to minimize their driving and, in the process, minimize the costs they impose on society in air pollution, highway maintenance and accidents.

A pay-as-you-drive (PAYD) system of insurance in Arizona might work this way: vehicle insurance could be split between those components in which risk is directly related to the ownership of a vehicle (comprehensive) and those in which risk is largely related to driving (collision, liability). The former could be charged to consumers on an annual basis, as is done currently. The latter types of insurance could be sold in chunks of mileage—for example 5,000 miles—or be sold annually with the adjustments of premiums based on actual mileage taking place at the end of the year. Of critical importance to the success of the system would be the creation of accurate, convenient methods of taking odometer readings and communicating them to the insurer.

A pay-as-you-drive system of insurance would have broad benefits for Arizona—not only for reducing global warming pollution, but also for improving highway safety and reducing insurance claims. Because insurers would still be permitted to adjust their per-mile rates based on other risk factors, mileage-based insurance would add additional costs for the worst drivers, giving them a financial incentive to drive sparingly.

Most importantly, however, a mileage-based insurance system would reduce driving. Converting the average collision and liability insurance policies to a per-mile basis in Arizona would lead to an average insurance charge of about 6.4 cents per mile.[64] (For comparison, a driver buying gasoline at $2.50 per gallon for a 20 MPG car pays 12.5 cents per mile for fuel.)

If 80 percent of collision and liability insurance were to be assessed by the mile, the impact on vehicle travel would be significant. Research conducted by the U.S. EPA and updated by the Victoria Transport Policy Institute suggests that a per-mile charge of this magnitude (about 5.1 cents per mile in Arizona) would reduce vehicle-miles traveled by about 8 percent, with carbon dioxide emissions from light-duty vehicles declining by roughly the same amount.[65] If all Arizona drivers were covered by the PAYD option, light-duty vehicle miles traveled—and therefore, light-duty vehicle carbon dioxide emissions—could be reduced by 4 percent.

While many insurers remain resistant to the administrative changes that would be needed to implement mileage-based insurance, the concept is beginning to make inroads. The Progressive auto insurance company offered a pilot PAYD insurance system in Texas and other pilot programs are underway elsewhere. In 2003, the Oregon Legislature adopted legislation to provide a $100 per policy tax credit to insurers who offer PAYD options.[66]

Arizona should choose to introduce the concept of PAYD by requiring insurers to offer it as an alternative to traditional insurance. If the concept proves successful, the state (or insurers) could then require liability and collision rates to be expressed in cents-per-mile—thus maximizing the carbon dioxide emission reductions and other positive results of the policy.

Strategy #5

Reduce Growth in Vehicle Miles Traveled

Potential Savings: 4.4 MMTCO$_2$ by 2015; 10.7 MMTCO$_2$ by 2025.

The growth in vehicle-miles traveled (VMT) over the last several decades has its roots in many societal changes—rapid population growth in Arizona, low gasoline prices, the increased participation of women in the workforce, and residential and commercial suburban sprawl.

Reversing this trend will be difficult, but success would bring benefits not only in reducing global warming emissions but also in easing traffic congestion, reducing public expenditures on highways, enhancing Arizona's energy security, and reducing automotive emissions of other pollutants that damage public health. Arizona should seek to reduce the growth rate in vehicle-miles traveled to half the rate of population growth in the state, projected by the U.S. Census Bureau to be approximately 2.46 percent per year between 2005 and 2025.[67] Reducing VMT will reduce greenhouse gas emissions as well as the other air pollution that plagues Arizonans and contributes to numerous public health problems.

The impact on vehicle-miles traveled of both transit improvements and growth management polices has been well documented. A variety of studies have documented that doubling the residential density of a given neighborhood reduces per-capita vehicle miles traveled by approximately 20 to 38 percent. Increasing the density of transit services has also been shown to reduce vehicle miles traveled.[68] Mixed use zoning also reduces vehicle travel by allowing people to walk or bicycle to work, stores and leisure activities.

Because such effects are dependent on the characteristics of the community and the type of proposed policy, it is difficult to estimate the impact of any one statewide smart growth strategy. Regardless, by adapting a package of "smart growth," transit, and transportation demand management (TDM) policies, Arizona could encourage long-term shifts in development patterns and transportation decisions that would provide benefits in reduced vehicle travel and global warming emissions.

Among the policies that could be implemented relatively quickly to help achieve this goal are:

- Directing state investments in transportation and other infrastructure towards designated growth areas or existing population centers, not to areas where increased access will promote more sprawl.
- Expanding bike trails and bike lanes, employing "traffic calming" techniques in town centers, requiring sidewalks in all developments, planting trees and offering other amenities that make walking more pleasant, and adopting other policies to improve the safety and appeal of walking and biking.
- Improving the geographic reach, quality and frequency of existing transit services, and working to achieve low fares that maximize the use of existing transit infrastructure.
- Providing additional incentives to employers who encourage telecommuting, establish carpool and vanpool programs, provide transit subsidies, or otherwise promote transportation alternatives.

Other policies are available to reduce how much Arizonans must drive, but may require more time to implement:

- Establishing growth management plans that include urban growth boundaries or boundaries for public services will lead to more compact development.
- Encouraging location-efficient mortgages that allow households living near transit services or regional employment centers to borrow additional money because their reduced transportation expenses increase their disposable income.
- Promoting mixed use development that includes commercial and residential activities in the same building or on the same street. This can reduce the need for driving by placing more destinations within walking distance.
- Promoting "infill" development, reuse of buildings no longer needed for their original purpose, and redevelopment in existing urban and suburban areas through transfers of development rights, brownfield redevelopment incentives, urban development programs, and other means.
- Creating a permanent state fund with a dedicated revenue stream to implement mass transit programs and oversee transit-related global warming emission reduction programs.

Regardless of the specific policies involved, Arizona must recognize the integral relationship of land use and transportation policies, and should align those policies to reduce automobile dependence, reduce development pressure on the state's remaining open spaces, and revitalize urban areas. By adopting a state goal for the management of vehicle travel and implementing that goal through a series of locally appropriate policies, Arizona could go a long way towards curbing global warming pollution.

Strategy #6

Implement a Renewable Fuels Standard

Potential Savings: 1.99 MMTCO$_2$ by 2015; 4.87 MMTCO$_2$ by 2025.

Arizona can reduce its petroleum dependence, while reducing global warming pollution, by enacting a renewable fuels standard. A renewable fuels standard would require that a certain percentage of the gasoline and diesel sold in Arizona consist of biomass-based renewable fuels, such as ethanol or biodiesel.

Biofuels are typically made from such crops as corn, soybeans, rapeseed (from which canola oil is derived) or even mustard

seed. New technology that allows cellulose from plant waste or "energy crops" (such as switchgrass) to be turned into fuel holds the promise of even greater energy and global warming emission benefits.

Renewable fuels are typically mixed with petroleum-based fuels, such as gasoline or diesel. All vehicles are capable of using fuel with a small percentage of renewables. Vehicles that run on higher percentages of ethanol, however, require special equipment and special infrastructure to deliver the fuel. However, they also provide much greater environmental advantages than vehicles using smaller percentages of renewable fuels.

A requirement that 10 percent of Arizona's gasoline consist of ethanol (increasing to 15 percent after 2010) and that 2 percent of diesel fuel consist of biodiesel (increasing to 10 percent after 2010) would be a reasonable goal for the state to achieve. A number of other states have successfully implemented similar types of renewable fuels standards. Minnesota recently began to require that biodiesel make up a small portion (2 percent) of all diesel fuel sold in the state and many states—such as California, Colorado, New York, Iowa and several other Midwestern states—now use ethanol as an oxygenate in gasoline. During the winter months, gasoline sold in Phoenix and Tucson contains approximately 2.8 percent ethanol.[69]

As Arizona moves forward with a renewable fuels standard, it is important that the state promote those processes that result in the greatest net energy balance and the greatest global warming benefit. The state should consider standards, incentives and other policies that encourage cellulosic biofuels to make up an increasing share of the state's biofuel supply. The state should also ensure that implementation of the renewable fuel standard does not adversely affect air quality. Because higher blends of ethanol-based fuel, such as E85 (85 percent ethanol and 15 percent gasoline) have both a greater ability to reduce global warming emissions and a lower potential to have adverse smog and air toxics impacts, the state should help to promote the use of E85 vehicles. This can be achieved both by leading the way and filling state-owned flexible fuel vehicles with E85, and by helping to develop the separate fueling infrastructure that is needed to refuel these vehicles. Similar efforts can also be made to promote the use and availability of higher blends of biodiesel.

Reducing Emissions from Homes, Businesses and Industry

The residential, commercial and industrial sectors are responsible for roughly 20 percent of Arizona's direct emissions (emissions from sources other than electricity generation) of carbon dioxide. These sectors are also the principal consumers of energy generated by the electric sector. There are tremendous opportunities to improve the efficiency of energy use in homes, businesses and industry. By updating and enforcing the state's building energy codes, expanding strong energy efficiency standards for appliances, and expanding energy efficiency programs, Arizona can ensure that it is getting the most out of every unit of energy it consumes.

Strategy #7:

Expand Energy Efficiency and Conservation Programs

Potential Savings: 3.87 MMTCO$_2$ by 2015; 9.06 MMTCO$_2$ by 2025.

One of the most promising opportunities for reducing carbon dioxide emissions in Arizona is through improved energy effi-

ciency. Stronger residential and commercial building codes and improved appliance efficiency standards (discussed below), while important, are limited in their scope, leaving many existing buildings and sources of energy untouched.

Energy efficiency improvements are among the most promising and least costly ways Arizona can reduce global warming emissions. But there are several hurdles to overcome. Potential users may not know about the technologies or have an accurate way of computing the relative costs and benefits of adopting them. Even when efficiency improvements are plainly justifiable in the long run, consumers may resist adopting technologies that cause an increase in the initial cost of purchasing a building or piece of equipment. In some cases, as with low-income individuals, consumers may not be able to afford the initial investment in energy efficiency, regardless of its long-term benefits.

The move toward electric industry restructuring in the late 1990s brought about a new era of utility sector energy efficiency mechanisms, broadly categorized as public benefits (or system benefits) funds and charges.

In 1994, Arizona passed a law to begin deregulating its electricity system, but after witnessing the problems of deregulation in other states, Arizona has moved slowly.[70] As part of the restructuring process, Arizona adopted a requirement that utilities develop energy efficiency education and assistance plans to reduce energy consumption and costs.[71]

In 2005, Arizona Public Service and Salt River Project, plus a few smaller utilities, spent approximately $9 million, or 0.2 percent of revenues, on efficiency programs.[72] Spending on electricity and natural gas efficiency programs is projected to rise to $35 million in 2006.[73] Arizona Public Service and Salt River Project offer information and advice to residential and business customers on how to save energy.[74] Salt River Project also offers on-site energy audits to commercial customers.[75] In partnership with the U.S. Department of Energy, the Arizona Department of Commerce's Energy Office runs the Rebuild Arizona program that seeks to reduce energy use in existing large residential or commercial buildings by 25 percent.[76] The program offers energy audits and loans of up to $500,000 to help retrofit buildings to reduce energy use.

Arizona needs to more aggressively pursue energy efficiency opportunities across the entire state.

- The state should require that 3 percent of total utility revenues be spent on cost-efficient energy efficiency measures. This would put funding for Arizona's program on par with the per-customer funding from states with the most successful programs.
- All energy providers in the state should be required to develop and implement efficiency programs to capture cost-effective efficiency potential. (The cost of providing energy should include not merely capital and fuel costs, but also environmental consequences of mining and burning fossil fuels.) In addition to requiring independent measurement, verification, and reporting of program expenditures and energy savings achieved, an efficiency program should lay out consequences for non-compliance.

Customers across the entire state should have access to energy efficiency programs, regardless of what utility provides power, whether investor-owned utilities, municipal utilities, cooperatives or federal projects. Each utility could create its own program to help customers reduce power use, or the utilities could jointly fund a single statewide program by pooling a portion of their revenues.

The near-term impacts of expanded residential, commercial, and industrial electricity and natural gas efficiency programs may

represent just the tip of the iceberg of the potential benefits of an expanded cooperative state and utility driven energy efficiency program. By promoting research and development of efficient new technologies and practices, and by broadening public understanding of the potential benefits of energy efficiency, these programs can create new opportunities for cost-effective energy savings in the years to come.

Strategy #8

Expand Appliance Efficiency Standards

Potential Savings: 0.60 MMTCO$_2$ by 2015; 1.10 MMTCO$_2$ by 2025.

Arizona has the power to adopt energy efficiency standards for a range of residential and commercial appliances. The state adopted standards for 12 products in 2005. Adding standards for more appliances can save Arizona consumers money over the long haul and reduce the state's consumption of energy.

Household appliances and those used by businesses are a major source of energy demand. Since the first state appliance efficiency standards were adopted in the mid 1970s (followed by federal standards beginning in the late 1980s), the energy efficiency of many common appliances has dramatically improved. For example, residential refrigerators consume less than one-third the electricity annually of refrigerators manufactured in the early 1970s despite the fact that today's refrigerators are larger and have more features.[79]

The federal appliance standards program has led to great improvements in the efficiency of many appliances, but the federal government has often been slow to keep up with advances in efficiency technologies or to take advantage of known efficiency opportunities. Though new federal standards were adopted for 15 appliances in the summer of 2005—including appliances

Energy Efficiency Standards in the 2005 Federal Energy Policy Act

In July 2005, Congress passed the Federal Energy Policy Act which included energy efficiency standards for 15 new products, including commercial refrigerators, commercial heaters, ceiling fan lights, traffic signs, and other home and business products. Nationally, these standards are expected to save almost 30,000 MW of capacity and 90 billion kilowatt-hours by 2020, which would offset about 2 percent of total electricity use.[82]

Many of the efficiency standards included in the legislation were added as a result of state work on efficiency standards. In the previous three years, a number of states—including Arizona, Washington, Oregon, California, Connecticut, New York, Rhode Island, New Jersey and Maryland—had adopted many of the efficiency standards subsequently included in the federal bill.[83]

Despite the many new federal efficiency standards, there remain significant opportunities for states to act. By taking state action to reduce energy consumption from items not covered by the federal standards, Arizona can save energy, reduce global warming emissions, and lead the way for future nation-wide adoption of additional efficiency standards.

Improved Energy Efficiency Can Protect the Economy During an Energy Crisis

Improving energy efficiency reduces electricity costs and global warming emissions. But it also has another benefit: it can be deployed quickly to protect the economy during an energy crisis. No experience demonstrates this potential as well as the response of California to the energy crisis of 2000-2001.[77]

In the late summer of 2000 and early 2001, California experienced periodic rolling blackouts and more than 70 days of electric system emergencies, with power supplies barely enough to meet demand. The outlook for the summer of 2001 was gloomy: the California Energy Commission anticipated a 5,000 MW power shortage and further rolling blackouts.

In response, California greatly expanded its energy efficiency programs by increasing funding for energy efficiency by 250 percent and launching a variety of initiatives to curb power use. State agencies provided appliance rebates, commercial lighting retrofits, and assistance to low-income households, while state and local governments took aggressive action to reduce their own power use. The state conducted an expedited update of its building energy codes and appliance standards. Investor-owned utilities expanded their existing efficiency programs and were required to give customers a 20 percent rebate on their electric bills if they reduced consumption by 20 percent during the summer of 2001.

The effort paid off, reducing California's peak power demand by 10 percent and preventing any rolling blackouts, saving billions of dollars. Indeed, power consumption in California in 2001 was 6.7 percent lower than in 2000. These electricity savings cost approximately $0.03 per kWh over the lifetime of the measures, less than half of what the state would have spent had it attempted to build new power plants and produce additional power.[78]

covered by standards Arizona adopted earlier in the year—many opportunities remain for improving appliance efficiency.

States are pre-empted from adopting their own efficiency standards for products covered by federal standards, but there are two opportunities for states to take action. First states may adopt efficiency standards for products not specifically covered by the federal program. Second, states have the opportunity to apply for a waiver of federal pre-emption to apply stronger standards to products currently covered by a federal standard.

A study conducted by the American Council for an Energy-Efficient Economy (ACEEE) and the Appliance Standards Awareness Project (ASAP) assessed the potential energy savings that would result from improved efficiency standards for commercial and residential products. Work by ACEEE and ASAP provides the basis of our projected emissions savings for items such as pool pumps, external power supplies (which convert AC power from a wall outlet into lower voltage DC or AC power to power electronics like cell phones), specific types of lamp fixtures, and commercial walk-in freezers and refrigerators.[80]

Appliance efficiency standards are a win-win for Arizona's environment and economy. The ACEEE and ASAP study estimates that adoption of the package of appliance standards would bring Arizona approximately $651 million in new economic benefits by 2030.[81] By 2025 the standards would also reduce carbon dioxide emissions by 1.10 $MMTCO_2$.

Arizona should adopt efficiency standards for additional appliances, both those not covered by federal rules and those that are covered by weak federal standards (for which Arizona must apply for waivers of pre-emption). In addition, the state should allow for the expedited adoption of future appliance standards set by large states, such as California, for existing products and new products making their way into the marketplace.

Strategy #9

Update Residential and Commercial Building Energy Codes

Potential Savings: 2.64 $MMTCO_2$ by 2015; 7.92 $MMTCO_2$ by 2025.

Nearly half of all energy use in the U.S. and in Arizona can be linked to buildings—whether residential, commercial or industrial. In addition to the energy consumed for heating, cooling and lighting in our homes, the places we work, and the places we shop and do business, there are a number of large appliances—such as refrigerators and washing machines—that consume energy in buildings. The importance of energy-conscious building design and construction is magnified by the fact that most buildings have a life span of at least 50 years, during which time the amount of "fixed" energy needed to heat, cool, ventilate and light the building remains fairly constant.

Building codes were originally intended to ensure the safety of new residential and commercial construction. In recent years, however, building codes have been used to reduce the amount of energy wasted in heating, cooling, lighting and the use of electrical equipment.

Model building energy codes are developed and updated at the national and international level. The International Energy Conservation Code (IECC)—developed by the International Code Council (ICC)—serves as the basis for many state codes. The latest full version of the IECC was released in early 2006. The new version is approximately half the length of the previous IECC code book, making it easier to read, understand, use and enforce.[84]

Arizona has not adopted mandatory energy standards for buildings.[85] Instead, the state has adopted the 2000 IECC as a voluntary standard and 21 local governments have established building codes with an energy efficiency component. Several different codes are currently in use in the state. For example, Pima County and the city of Tucson have adopted the 2000 IECC while the Maricopa Association of Governments uses the International Residential Code, which draws upon the IECC.

All buildings in Arizona should be built to the same high level of efficiency. While this may require a break with Arizona's home rule tradition, the adoption of statewide energy codes and performance standards would have a significant effect on our ability to control global warming emissions.

Thanks to efforts by local utilities, builders and state government to ensure homes meet strict performance measures, many new homes in Arizona are built to higher energy standards than required by local codes. More than 20,000 homes meet Energy Star standards as of July 2003, or 20 percent of all Energy Star homes constructed nationwide.[86] The Energy Star standard is a voluntary federal program that certifies homes as at least 30 percent more efficient than the 1993 Model Energy Code.

The Arizona Department of Energy and utility companies have helped train

contractors to install efficient equipment and seal ducts tightly. Many major builders, encouraged by utility company programs, offer guaranteed low heating and cooling costs on new homes.[87]

Through stronger codes and performance measures, Arizona could reduce energy consumption in new residential and commercial buildings. State government could offer expanded training to contractors in how to identify energy efficiency opportunities and install efficient equipment; offer incentives for buildings that meet a higher standard than Energy Star; and establish more ambitious performance standards to recommend to local governments. City and county governments should adopt the most recent building codes and strongest performance standards available, as well as ensure that builders are meeting local requirements.

Assuming that Arizona achieves the savings identified in the strong improvement scenario of the Southwest Energy Efficiency Project's study of building energy use, Arizona could reduce energy consumption in new residential and commercial buildings by 33 and 36 percent, respectively, by 2025.[88] These savings reflect energy efficiency improvements in new construction—applying codes to renovations in existing structures would result in even greater savings.

Across the country, a variety of private and governmental entities have demonstrated the feasibility of more aggressive building energy codes.

- **Energy Star Certification** – Arizona leads the nation in the number of Energy Star-certified new homes, with 7,000 new qualified homes in 2001. Energy Star homes are independently verified to be at least 30 percent more energy efficient than homes built to the 1993 national Model Energy Code.[89]
- **Strong State Codes** – The state of Oregon has set building energy codes that are approximately equal to federal Energy Star standards. Oregon credits strong building codes for 35 percent of the state's total energy efficiency savings.[90]
- **Leadership in Energy & Environmental Design (LEED) Standards** – Commercial buildings certified to the LEED standards use an average of 30 percent less purchased energy than conventional buildings. While LEED-certified buildings cost an average of 2 percent more to construct, they yield 20-year financial benefits of about 10 times the construction premium.[91] LEED silver, gold, and platinum buildings are held to even higher energy-efficiency standards.

Strategy #10

Expand Use of Combined Heat and Power and Local Power Generation

Potential Savings: 3.82 MMTCO$_2$ by 2015; 4.80 MMTCO$_2$ by 2025.

Arizona has many opportunities to promote the use of combined heat and power, in which wasted energy from electricity generation is captured and used for other purposes, and the local generation of power, which reduces the inefficiencies created by the long-distance transportation of power.

America's electricity system is a good source of reliable power, but it also loaded with inefficiencies. Power plants produce a large amount of waste heat during their operation, which reduces their efficiency at converting the energy in fossil fuels into electricity. Similarly, the nation's long-distance transmission system results in the loss of between 5 and 10 percent of the electricity that crosses the wires on its way from power plants to homes and businesses.[92]

Arizona could reduce energy waste by promoting the use of combined heat and power (CHP) systems and local, distributed

generation (DG) of electricity. CHP systems pair electricity generation and heating—enabling the waste heat from electricity generation to be used to provide space or water heating or to assist in industrial processes. While the average American power plant operates at a thermal efficiency of about 35 percent, CHP plants can achieve efficiencies of 80 percent or greater, meaning that more of the energy that goes into the plant is available for useful work.[93]

Various forms of CHP are already in use in Arizona, accounting for more than 810 megawatts of generation capacity.[94] The University of Arizona has installed two gas-fired turbines on campus that generate electricity and provide heat, saving $3 million annually on utility expenses.[95]

Many CHP systems are also a form of distributed generation (DG). While not all forms of DG recapture waste heat, they do reduce the loss of energy over long-distance transmission wires and promote greater grid stability. Among the many types of DG technologies are solar panels, small wind turbines, fuel cells and natural gas microturbines.

Both CHP and DG systems have been hampered by utility and regulatory policies that make it difficult for them to connect to the electric grid and to receive fair value for excess power sold back into the system. Arizona does allow net metering for CHP systems.[96] But the state should take additional actions to identify and reduce barriers to CHP and DG. Such barriers typically include burdensome interconnection requirements (which the Arizona Corporation Commission is trying to address), unreasonably high standby power charges, and other regulatory barriers. In addition, the state should actively assist and promote the deployment of CHP.

In a 2002 study, Western Resource Advocates estimated that Arizona could install as much as 805 MW of new industrial and commercial CHP generating capacity by 2020.[97] The carbon dioxide savings estimate here assumes that this target is met. However, the estimate does not include savings that could accrue from residential CHP or from expansion of DG. Encouraging the deployment of these technologies would lead to additional pollution reductions in Arizona.

Additional Residential, Commercial and Industrial Sector Strategies

A number of other strategies are available to reduce energy use in the residential, commercial and industrial sectors.

- **Energy-Efficient Mortgages and Pay-As-You-Save Programs** – Energy-efficient mortgages (EEM) and pay-as-you-save (PAYS) programs are alternative models for financing the installation of energy-efficient measures and distributed generation resources, primarily in the residential sector. EEM programs generally allow homebuyers to assume larger mortgages (sometimes on preferential terms) to finance energy efficiency improvements. PAYS programs allow consumers to pay for energy-efficient equipment or distributed generation resources (such as solar panels, small wind systems or fuel cells) over time on their utility bills rather than up-front. The charge remains on the utility bill until the equipment is paid off, regardless of who is living in the residence at the time. PAYS systems remove a major barrier from homeowners seeking to reduce energy demand: the prospect that they will not reside at the home long enough to enjoy the benefits of their investments. State officials should work with utilities to develop PAYS programs that are applicable to both efficiency and distributed generation, and they should also coordinate with mortgage lenders to encourage and publicize EEMs.

- **Promote Energy Smart Buildings** – In addition to strengthening building codes to promote energy efficiency, Arizona should identify ways to encourage more builders, businesses and home buyers to go beyond the minimum standard and build truly energy-smart buildings that are at least 50 percent more efficient than current standards. Energy-efficient certification programs, government-sponsored demonstration projects, advanced trainings for architects and builders and other types of incentives and programs should be considered. However, any program to promote green buildings should also reinforce the state's smart growth goals. Any "green" commercial building sited in such a way as to increase automobile travel may have a negligible—or even negative—net impact on global warming emissions.

- **Encourage Measures to Reduce "Heat Islands"** – Because asphalt and dark rooftops absorb more of the sun's heat than would vegetation or even light-colored materials, urban areas may be as much as 10° F warmer than surrounding areas.[98] This increases the need for air conditioning and causes cooling equipment to have to work harder to lower indoor air temperatures. Higher energy demand results in greater global warming pollution. Light-reflecting roofs, special pavement and more vegetation, implemented in a concentrated region, can help reduce the heat island effect and the amount of energy consumed for air conditioning. Cooling expenses, an indicator of energy consumption, for one public building in Tucson were reduced by 48 percent after a reflective roof was installed.[99] Phoenix and Tucson have begun to address the problem but could do far more.

- **Solar-Ready Home Standards** – Incorporating solar photovoltaic systems into new housing designs and construction has been key to the creation of a robust, self-sufficient solar market in other parts of the world. Japan, for example, is currently on track to meet its goal of installing building-integrated photovoltaic systems on half of all new homes by 2010.[100] An important step that would allow Arizona to follow suit would be to revise building codes to require that new homes and commercial structures be built to allow the easy installation of solar photovoltaic systems.

- **Cluster and Mixed Use Development** – Smart growth policies are commonly thought to reduce global warming emissions by reducing the number of automobile trips required to carry out our daily activities. But they may also have the secondary effect of reducing energy use within the buildings themselves. Many smart growth or "new urbanist" projects involve the renovation of existing buildings, construction of homes with less square footage than typical new suburban construction, or the combination of commercial and residential uses in a more space-efficient fashion. More research needs to be done to quantify the energy impacts of such projects, but Arizona can spur their development by encouraging towns to develop zoning ordinances that allow, or provide incentives for, cluster and mixed-use developments.

Reducing Emissions from Electricity Generation

In addition to efforts to conserve electricity, Arizona can also reduce carbon dioxide emissions from electricity use by making

electricity generation in Arizona cleaner—specifically by encouraging a shift away from carbon-intensive fuels such as coal and towards renewable energy sources such as solar and wind. To achieve this goal, Arizona must encourage the deployment of renewable energy sources while simultaneously adopting policies to reduce carbon dioxide emissions from fossil fuel generators. This shift is especially important given that Arizona's power plants are the largest source of global warming emissions in the state.

As an energy exporting state, Arizona has the opportunity to lead the way among energy producing states in reducing global warming emissions from electricity generation. Expanding the use of renewable sources of energy in the state—through both an expanded renewable portfolio standard and new incentives to develop Arizona's abundant solar resources—can help move the state toward a cleaner, more resilient energy system with less impact on the climate. Even with those steps, however, the state's carbon dioxide emissions still could rise if large projected expansions in coal-fired electricity generation over the next two decades actually occur. Arizona should stop any expansion in coal-fired generation and ensure that the state does not import equally carbon-intensive energy instead.

Strategy #11

Support the Development of Solar Energy

Potential Savings: 0.06 MMTCO$_2$ by 2015; 0.70 MMTCO$_2$ by 2025.

Solar energy is currently a small player in the generation of electricity in Arizona and around the country. However, solar photovoltaics (PV) and solar thermal technologies have the potential to make a major contribution to a clean energy future. Solar PV costs have gone down by 75 percent over the past 20 years.[101] And given its enormous potential for solar power, Arizona can play a leading role in positioning solar power to make a major contribution to the state energy system.

Solar energy represents one of the best long-term hopes for Arizona to slash its consumption of fossil fuels and emissions of carbon dioxide. By supporting the development of solar energy now, Arizona can be in a better position to fully reap the benefits in the decades ahead.

Solar Photovoltaics

Arizona currently offers up to a $1,000 tax credit to individuals who install solar photovoltaic systems or other renewable energy equipment.[102] Retailers and installers are allowed to exempt the first $5,000 of sales of solar and renewable energy equipment and projects from state and county sales tax. Arizona Public Service (APS) offers an incentive of $4 per Watt of installed solar photovoltaic capacity, covering up to half of the cost of a system for a consumer and providing the company with credits to use toward Arizona's renewable energy requirements.[103] APS committed $4.25 million to such incentives in 2005 and 2006. Salt River Project is committing $3.85 million to a similar program for its customers.[104] Both Tucson Electric Power and Unisource Energy Services offer smaller incentives to their customers.

While these efforts represent a strong start, there are other steps the state can take as well:

- **Expand incentives** for each Watt of solar photovoltaic capacity that homeowners or businesses install. New Mexico recently established a statewide solar tax credit that will provide $3 million annually in credits for solar PV installations.[105] The incentives will defray up to 30 percent of the cost of a solar PV system, with a maximum credit of $9,000.[106] Arizona could

adopt a comparable program for both residential and commercial customers, adjusted for the state's larger population, to encourage solar installation.

- **Improve net metering**. A key component to making solar power cost-effective involves fairly compensating owners of solar photovoltaic systems for the electricity they generate but do not consume, which typically occurs during the day. Salt River Project, Tucson Electric Power and Arizona Public Service offer versions of net metering and/or net billing. All utilities should offer net metering, at retail rates, without limits on system size and allow customers to be paid for all power they generate if they produce more than they consume in a year.
- **Incorporate solar into new home design and construction**. Arizona builds thousands of new single-family homes each year. Incorporating solar PV systems into homes during construction is one of the most cost-effective and efficient ways to build the state's solar market. Policies targeted specifically at new homes—such as requirements to install solar on an increasing percentage of new homes or offer systems to homebuyers—can develop one of the most cost-effective parts of the residential PV market.

  Homes equipped with solar panels reduce energy bills for homeowners, potentially increasing the amount of income they can afford to spend on a mortgage and boosting their satisfaction with their home. More than half of California homeowners who recently purchased a solar home did so to save money and more than 80 percent believe the solar panels will be a positive feature when reselling the home.[107]

Arizona should work toward the goal of having the equivalent of 315,000 new solar rooftops in the state by 2025, a number equal to 20 percent of new homes.[108] Achieving this goal would not only reduce carbon dioxide emissions, but would also enhance the stability of the state's electric system and create economies of scale that will make solar power a cost-effective alternative for Arizona homeowners and businesses within the next two decades. The state would then be poised for a dramatic increase in solar installation in subsequent years, precisely when the state will be seeking deep reductions in its global warming emissions in keeping with the long-term goal of preventing further harm to the climate.

Solar Thermal Energy and Passive Solar

Using the sun's rays to generate electricity is just one of many ways to use solar energy to reduce the use of fossil fuels and cut global warming emissions.

Solar hot water systems use solar energy to produce hot water for bathing, laundry and other household uses. Installation of a rooftop solar hot water system can reduce energy consumption for water heating by about two-thirds.[109] Passive solar building design uses appropriate building layouts and the judicious use of glass to light and heat interior building spaces. Solar energy can even be used to heat and cool buildings.

Many solar hot water systems and passive solar designs have the advantage of being less expensive to implement (and often more cost-effective) than solar PV systems. Arizona's tax credit for the installation of solar energy systems is a strong step to promote solar energy. Incentives or standards for energy-efficient buildings could encourage the development of buildings that use passive solar heat and light.

Solar hot water systems and passive solar energy have great potential to reduce fossil fuel consumption in Arizona. The estimate of carbon dioxide pollution reductions above, however, only includes energy savings from solar PV.

Strategy #12

Strengthen the Renewable Energy Standard

Potential Savings: 8.25 MMTCO$_2$ by 2015; 18.9 MMTCO$_2$ by 2025. (Emission reductions are in addition to savings achieved with the state's proposed 15 percent renewable energy standard.)

Like many states around the country—including other western states such as New Mexico, Colorado, Nevada, California, Texas and Montana—Arizona has adopted a renewable energy standard (RES) for electricity supplied to that state's costumers. Essentially, an RES requires that a certain portion of the power delivered by the utilities be from renewable energy sources. The percentage of renewable power increases over time, providing a scheduled ramp-up to the provision of a significant portion of the state's power from renewable sources.

Arizona first adopted an RES in 1996 that focused heavily on promoting solar energy.[110] Draft revisions proposed by the Arizona Corporation Commission in March 2006 will, if approved in a formal rulemaking, require that 15 percent of electricity sold in the state in 2025 come from renewable sources. A portion of that must be in the form of distributed generation, power generated on-site at homes and businesses, or solar equipment such as solar hot water heaters that will replace the need for electricity or natural gas. In 2007, 5 percent of the renewable energy must be distributed, increasing to 30 percent in 2011 and beyond.[111] The draft rules define renewable energy sources as solar, wind, some hydropower, geothermal, fuel cells that are not fossil fueled, and biomass resources.[112] Distributed generation technologies include solar and small wind power, daylighting and other solar technologies, geothermal heating and biomass. Currently, the standard applies to only five major electricity suppliers that serve approximately half of the state's customers.

Arizona should expand its current RES so that by 2025, 30 percent of electricity consumed in Arizona is from new renewable energy sources. The Arizona Corporation Commission currently does not have the power to require municipal utilities or Salt River Project to meet the RES goal. Assuming that the current RES is extended to a goal of 30 percent and all power sold to the state's consumers is covered, Arizona would achieve savings of 18.9 MMTCO$_2$ by 2025 beyond what would be saved through the state's proposed 15 percent RES.

Not only is such an increase in renewable energy production in Arizona feasible, but the state's abundance of sun—a key ingredient for renewable power production—ensure that even with today's technology, such an increase would realize only a fraction of the state's full renewable energy potential.

In terms of raw resources, Arizona is the solar energy capital of the United States. With more than 300 days per year of sunshine, Arizona is ideally suited for generating electricity from the sun. Solar panels covering an area measuring 14 by 20 square miles, or less than one quarter of one percent of Arizona's land mass, could generate enough energy to meet the state's entire electricity needs.[113]

In addition, Arizona has moderate wind resources, concentrated north and southeast of Flagstaff, as well as in the Kingman area. Wind energy could produce up to 5 million MWh per year in the state.[114] Biomass and geothermal energy technologies hold a similar potential for electricity generation in Arizona, up to 6 million MWh per year.[115]

In sum, filling a 30 percent renewable portfolio standard for Arizona with either solar or wind alone would require the development of a fraction of the state's potential renewable energy resources—even without factoring in future technology improvements that could make solar panels more effective at turning the sun's energy into electricity and wind power feasible at lower wind speeds. Adding other types of

renewable energy to the mix—such as landfill gas, geothermal and clean biomass (that which does not contribute to toxic air emissions)—makes the goal of renewably generating 30 percent of all electricity consumed in Arizona by 2025 even more feasible. Renewable energy imported from other states could also be used to satisfy requirements of the RES.

As Arizona considers how to enforce, strengthen and expand its RES, it should adhere to its current commitment to truly clean, truly renewable technologies. Polluting and environmentally damaging technologies, along with those that rely upon non-renewable resources, should continue to be excluded from use to fulfill RES requirements.

Strategy #13

Prevent Expansion of Coal-Fired Power Generation in Arizona

Potential Savings: 47.6 MMTCO$_2$ by 2025.

One of the most important things Arizona can do to combat global warming in the next two decades is to prevent the dramatic expansion of coal-fired electric generation capacity and to develop strategies to replace existing coal-fired generation with less polluting and more efficient alternatives.

Rising natural gas prices are leading to a nationwide "coal rush" as utilities and merchant electricity generators seek to serve rising demand for electricity. Across the country, 135 new coal-fired power plants have been proposed—enough to generate power for 80 million homes.[116] In Arizona, construction is nearing completion on a new 400-megawatt coal plant near Springerville, and an additional unit of the same size has been proposed and permitted. The rise in the number of proposed coal-fired power plants in Arizona and elsewhere could more than offset state and national efforts to reduce global warming pollution.

Coal-fired electricity generation produces more carbon dioxide per unit of energy produced than virtually any other option for generating power. In 2002, Arizona's coal-fired power plants produced nearly 1.1 tons of carbon dioxide for every megawatt-hour of power produced, compared to 0.5 tons for every megawatt-hour of power produced from natural gas.[117]

Under a business-as-usual scenario, emissions from coal-fired power plants are projected to increase dramatically. The U.S. Energy Information Administration (EIA) projects that, between 2015 and 2025, the amount of coal-fired generation capacity in the Mountain West will increase by roughly 70 percent.[118]

Allowing the dramatic expansion of coal-fired power plants would likely doom the state's efforts to reduce global warming pollution. Thankfully, however, alternatives do exist for Arizona to meet its energy needs without dramatically expanding production of power from coal.

Reduce Growth in Electricity Consumption and Production

Improving the energy efficiency of Arizona's economy and expanding clean distributed generation will reduce dependence on power from large, centralized power plants. Many of the policy recommendations in this report will move Arizona in this direction, but more remains to be done. A 2002 report by the Southwest Energy Efficiency Project (SWEEP) estimated that Arizona could cost-effectively reduce its consumption of electricity by 34 percent below status-quo projected levels by 2020.[119] A more recent report for the Western Governors' Association found that a 20 percent reduction in energy use by 2020 should be both feasible and cost-effective.[120] By contrast, the specific policy options proposed here—stronger efficiency programs, appliance standards and building codes—capture only a portion of that potential, bringing the state only to stabilization of emissions by 2025. Arizona

clearly has further energy efficiency opportunities. There are a number of policies available to Arizona to capture more of this energy efficiency potential and reduce demand for power from coal-fired power plants.

One way to expand investment in cost-effective energy efficiency is to ensure that efficiency is considered as an alternative to new power plants in the utility regulatory process, and that it is treated fairly. Saving energy through improved efficiency generally costs less than building and operating new power plants, and it certainly costs less if the economic threat of global warming is considered. Utilities should be required to develop resource plans that include the consideration of energy efficiency, renewable energy and other cleaner sources alongside fossil fuel-fired power plants in serving future power demand. This would result in energy efficiency taking on a larger role in Arizona's energy supply system and would reduce demand for new power plants.

However, emissions from Arizona's power sector depend on more than just what happens inside the state's borders. Arizona is a net exporter of electricity to the region, so regional measures to improve energy efficiency and reduce demand for power across the West could also reduce the demand for new power plants in Arizona.

Consider the True Cost of Coal-Fired Power Plants

Coal-fired power plants currently have a series of economic advantages over cleaner sources of energy. Coal-fired power plants are not forced to account or pay for the many environmental and social costs they impose—costs ranging from the public health damage caused by air pollution and unregulated mercury emissions to the use of increasingly scarce water for plant operations. In addition, many older coal-fired power plants are exempt from modern clean air standards, and their carbon dioxide emissions are significant contributors to global warming, extreme weather events, economic uncertainty and ecological disruption. Excluding these costs makes coal-fired power production in Arizona look artificially cheap.

Considering the true cost of coal-fired power plants in utility regulatory proceedings would tend to give a leg up to lower-carbon sources of electricity—such as natural gas and renewables. It could provide an incentive to replace existing, inefficient power stations with cleaner, more efficient technologies—possibly including technologies to capture and store carbon dioxide. (See "Gasified Coal and Global Warming.")

The California Public Utilities Commission requires utilities to include the cost of controlling or mitigating global warming emissions into their estimates of fuel costs from different sources. Utilities filing plans in California must budget $5 per ton of carbon dioxide in the near term, $12.50 per ton beginning in 2008 and $17.50 by 2013.[121] Another way to ensure that the global warming-related costs of coal-fired power plants are included in the cost of electricity is to adopt a carbon "cap and trade" system in Arizona.

Create a Carbon "Cap and Trade" Program

"Cap and trade" systems are among the most widely considered options for limiting carbon dioxide emissions from electricity generation. The system begins with a "cap" that limits the total amount of carbon that can be released by electricity generators. A strong cap will produce greater reductions in overall emissions.

In the Northeastern U.S., eight states recently agreed to create such a program, called the Regional Greenhouse Gas Initiative (RGGI). The initiative calls for emissions from the region's power producers to stabilize at 2009 levels until 2015 and then to be cut by 10 percent below that level by 2019.[127]

The RGGI agreement sets a cap on

Gasified Coal and Global Warming

Gasified coal (often called "clean coal") is being promoted as an environmentally responsible way to use coal to generate electricity. Gasified coal technologies, such as integrated gasification combined cycle (IGCC) coal-fired power plants, have important advantages over conventional coal-fired power plants: they are significantly more efficient and have lower emissions of conventional pollutants.[122] In addition, IGCC technology allows for the capture of carbon dioxide, which some believe can be stored in large quantities underground—theoretically allowing for the production of low- or zero-carbon power from coal.

However, coal gasification is far more expensive than cleaner and more sustainable ways of addressing our nation's energy-related and environmental problems. Coal gasification with carbon storage is more than twice as expensive as typical energy efficiency measures and more than 50 percent more costly than the best wind power projects.[123] Even without carbon storage, coal gasification would cost roughly twice as much as energy efficiency and could at best compete with an average wind farm.[124]

Moreover, carbon capture and storage—on the scale at which it must be implemented to fight global warming—is an immature technology with serious questions about its future viability. Carbon dioxide has been injected into the ground for some time to enhance oil recovery. However, the storage of captured carbon dioxide from utility operations, or from the use of coal gasification to create hydrogen fuel for automobiles, would require a vast expansion of carbon transportation infrastructure and storage. For example, storing all U.S. power plant coal emissions would require enough infrastructure to liquefy and store roughly 2 billion metric tons of carbon dioxide *annually*.[125]

Storing any quantity of carbon presents problems. As with nuclear wastes, carbon dioxide stored in geological formations must be guaranteed to remain underground for hundreds or thousands of years to prevent re-release to the atmosphere and to prevent accidental, large-scale releases of carbon dioxide, which can be fatal to humans and wildlife. Ocean storage, which has been considered a possible option for carbon management, appears less attractive given recent research tying increasing ocean carbon dioxide levels with damage to ocean ecosystems.[126]

Provided that the technological hurdles can be overcome, IGCC will likely only become a key player in the energy mix if policies are in place to make it economically competitive with conventional coal technology. A carbon cap that places a market price on carbon dioxide emissions from power plants could provide an incentive for cleaner technologies such as IGCC to develop. Even then, however, IGCC would only deliver global warming benefits if it were used as a replacement for the state's existing fleet of dirty and inefficient coal-fired power plants, not as an addition to them.

The Dangers of Nuclear Power

Nuclear power is often touted by the nuclear industry as the energy source for addressing global warming because it has low emissions of carbon dioxide. However, nuclear power is both more expensive than many other substitutes for fossil fuel-fired power generation (such as wind power and improved energy efficiency) and poses a series of unique threats to the environment and public safety. In addition, opening a nuclear power plant requires an extensive planning and construction process that means no electricity will be added to the grid for a decade, limiting the ability of nuclear power to help reduce emissions today.

The Palo Verde nuclear power plant west of Phoenix generates a great deal of electricity with negligible carbon dioxide emissions. However, the problems with nuclear power, explored below, make expanded nuclear power an inappropriate solution to global warming. Policies aimed at reducing carbon dioxide pollution should not directly or inadvertently support the already heavily subsidized nuclear industry.

- **Cost –** Nuclear power has proven to be expensive due to the high cost of building, maintaining and decommissioning nuclear reactors. But looking only at market costs obscures the more than $100 billion spent by U.S. taxpayers for research and development, protection against liability from accidents, and other subsidies for nuclear power.[129] Without these subsidies, the nuclear industry likely could not have survived, and new plants likely would not be built.
- **Accident risk –** In the short history of nuclear power, the industry has experienced at least two major accidents—at Three Mile Island and Chernobyl—that endangered the health of millions of people.[130] While the United States has thus far been spared an accident of the scale of Chernobyl, there have been numerous "near-misses." For example, in 2002, inspectors discovered a football-sized cavity in the reactor vessel head of the Davis-Besse nuclear reactor in Ohio. The damage was overlooked in previous inspections and went unnoticed for six years, despite similar damage occurring at other nuclear plants. According to a study performed by the Oak Ridge National Laboratory, the reactor vessel could have breached in as little as two months, potentially causing a core meltdown worse than Three Mile Island.[131]
- **Terrorism and sabotage –** In 2005, the National Academy of Sciences found that a terrorist attack aimed at the spent fuel storage pools at a boiling water reactor could cause a large radiation release, perhaps worse than Chernobyl.[132] The security record of nuclear power plants is far from reassuring. In tests at 11 nuclear reactors in 2000 and 2001, mock intruders were capable of disabling enough equipment to cause reactor damage at six plants.[133] A 2003 Government Accountability Office (GAO) report found significant weakness in the Nuclear Regulatory Commission's oversight of

security at commercial nuclear reactors.[134] As late as September 2004—three years after the September 11, 2001 terrorist attacks—GAO reported that the NRC had not yet implemented some of GAO's earlier recommendations and that the NRC is not yet in a position to assure that plants are able to defend against terrorism.[135]

- **Spent fuel –** Nuclear waste remains a serious problem without a safe solution. Nuclear power production results in the creation of tons of spent fuel, which must be stored either on-site or in a centralized repository. Both options pose safety problems. Centralized waste repositories require the transportation of high-level nuclear waste across highways and rail lines within proximity of populated areas. Once the waste arrives, it must be held safely for tens of thousands of years without contaminating the environment or public.

  On-site storage poses its own problems. Nearly all U.S. nuclear reactors currently store waste on site in water-filled pools, often at densities approaching those in reactor cores. Should coolant from the spent-fuel pool be lost, the fuel could ignite, spreading highly radioactive compounds across a large area. In 2005, the National Academy of Sciences (NAS) warned that "[s]pent nuclear fuel stored in pools at some of the nation's 103 operating commercial nuclear reactors may be at risk from terrorist attacks."[136] One study estimated that such an event would result in between 2,000 and 6,000 additional deaths from cancer.[137]

For these reasons and others, nuclear power should remain "off the table" as a potential means to reduce global warming emissions in Arizona.

power plant carbon dioxide emissions for each state. Power plants must hold an "allowance" (or permit) for every ton of carbon dioxide they emit to the atmosphere. States may choose whether to auction off the allowances or give up to 75 percent of them to power generators for free. States that choose to auction the allowances may then use the funds to promote energy efficiency improvements and non-carbon emitting forms of power, such as renewables. Any power plant owner that wishes to increase emissions must buy additional allowances from the owners of other power plants that have extra allowances to sell. In theory, this cap and trade system will lead to reductions in carbon dioxide emissions at the lowest aggregate economic cost.

A carbon cap and trade program could be adopted by Arizona alone, or by a group of western states. A regional cap and trade program would likely produce better results, as it reduces incentives to merely shift power generation out of Arizona and into neighboring states.

Impacts of Stopping the Expansion of Coal-Fired Generation

Arizona has several policy options, described above, for preventing a dramatic increase in coal-fired generation in the state in the years to come. Each of the options would produce different results in terms of the state's electricity consumption, its generation mix, and the degree to which it remains a power exporter to the region.

Arizona should begin with a moratorium on construction of new coal-fired power plants (Idaho has adopted such a ban for two years), providing time to establish a long-term energy plan.[128]

In estimating the benefits of stopping the "coal rush," we assume that emissions from coal-fired power plants in the state are held constant at projected 2008 levels until 2025. Should this generation be replaced with forms of generation that emit carbon dioxide, such as natural gas, the pollution reductions achieved would be less than estimated here.

In any case, Arizona must plan now for meeting its future energy needs with sources other than coal burned in conventional coal-fired power plants.

Public Sector and Other Strategies

Strategy #14

Public Sector
"Lead by Example"

Potential Savings: 1.51 MMTCO$_2$ by 2015; 3.02 MMTCO$_2$ by 2025.

State and local governments are significant users of energy in Arizona. Reducing energy use in the government sector not only has a direct impact on global warming pollution; it also sets an example for the private sector as to what can be achieved. The government should reduce its energy use in government buildings by 30 percent by 2015 and reduce global warming emissions from vehicles by 30 percent by 2015. At the same time the state government should aggressively increase its reliance on renewable energy by purchasing 20 percent its electricity from clean renewable sources by 2015 and 50 percent by 2025.

Arizona has already adopted some policies and practices—such as implementing energy conservation measures in state offices and requiring new executive branch facilities to meet enhanced energy efficiency standards and use more renewable energy—that reduce government's contribution to global warming.[138]

For example, the state has made significant advances in improving the energy efficiency of state- and university-owned buildings. Prompted by blackouts in California during the energy crisis of 2001, former Arizona Governor Jane Dee Hull ordered state agencies to turn up their thermostats and take other energy saving measures. As a result, the state reduced energy use by 7 to 10 percent and saved $115,000.[139]

Building on that success, in 2003, the Legislature passed and Governor Janet Napolitano signed legislation requiring state agencies and universities to improve building energy efficiency 15 percent by July 2011, to purchase appliances meeting Energy Star® standards and to ensure that new buildings meet updated efficiency standards.[140] In 2005, the Arizona Department of Commerce reported that state agencies had reached an average efficiency improvement of 7 percent and two state buildings officially earned the EPA Energy Star® label.[141] The Southwest Energy Efficiency Project estimates that this bill will deliver $90 million in savings for state government through 2015.[142]

In February 2005, Governor Napolitano took a step further, requiring executive branch agencies to meet at least the "silver" Leadership in Energy & Environmental Design (LEED) standard in any new construction projects.[143] The order also encourages other branches of state government to voluntarily follow the standards.

The state of Arizona should work to meet and exceed these goals by implementing and enforcing existing policies, while aggressively developing new programs and standards designed to reduce the state government's global warming emissions. The state should endeavor to:

1) Reduce energy use in state facilities by 30 percent by 2015.

The state government can achieve significant energy savings by reducing energy used in state facilities by 30 percent over the next nine years. Meeting this goal will require that the state implement an aggressive building retrofit program and design all new buildings (and major renovations) to consume at least 50 percent less energy.

Aggressive building retrofit program

The state should seek to retrofit at least half of all state buildings for improved energy efficiency. The Energy Conservation Savings Reinvestment plan operated by the city of Phoenix provides one possible model.[144] In this program, the city undertakes energy efficiency projects and reinvests 50 percent of the documented savings into a fund dedicated to advancing more efficiency projects. Similarly, the Arizona Department of Administration is authorized by statute to enter into efficiency performance contracts with efficiency service providers, with 50 percent of the money saved by the state reserved for further efficiency opportunities.[145]

These programs provide a good starting point, but they are not likely to deliver enough progress on their own. All branches of state government should develop a strategy to retrofit at least half of all state buildings for improved energy efficiency.

All new buildings and major building renovations should be designed to use at least 50 percent less energy

The state should set a standard that all new building projects and major building renovations be designed to use half of the energy currently consumed by the average new building of the same type and size in the United States, with a long-term goal of developing a carbon-neutral building standard by 2030. This standard should apply to all state government buildings, all public schools, all institutions of higher education, and any other building that receives at least partial state funding.

Arizona's requirement that executive branch agencies meet "silver" LEED standards in new buildings is a good first step toward this goal.[146] The city of Tucson has also started down this path—implementing a standard that all new municipal construction must be 50 percent more efficient that buildings designed with the old 1995 Model Energy Code (1995 MEC).[147] As a leader in the effort to reduce global warming emissions, the state should go farther and set an example of designing and constructing buildings that consume half the amount of energy as the average U.S. building.

Implementing a 50 percent more efficient standard would help lay the groundwork for more aggressive building design standards in the future. Ideally, the state's standards for new buildings would incrementally increase every five to 10 years so that by 2030 all new state-funded buildings would be carbon neutral in their energy use. A strong building standard would help reduce energy costs, decrease carbon dioxide emissions and set an example for the private sector to follow.

State-funded buildings could meet strong energy consumption goals through a combination of strategies, including:

- Energy-aware building designs that take advantage of natural lighting and maximize natural heating and cooling;
- Energy-efficient building materials—both construction materials that help reduce heating and cooling costs once installed (items such as insulation and energy-efficient windows) and materials that require less fossil fuels to manufacture (such as recycled brick, stone and steel);
- Energy-saving building appliances—large-ticket items such as lighting systems, water heaters, furnaces and air conditioners; and
- Electricity that comes from renewable sources, either in the form of solar panels and other types of on-site

renewable electricity generators, or from the energy grid.

2) Reduce government vehicle fossil fuel consumption by 30 percent by 2015.

Arizona should seek to reduce fossil fuel consumption from government sector vehicles. There are a number of ways Arizona could achieve a 30 percent reduction in global warming emissions from state government's fleet within the next nine years. These include:

- Requiring that state agencies purchase vehicles with the highest fuel economy for possible for their intended use.
- Running all diesel vehicles on B20 (a blend of 20 percent biodiesel and 80 percent gasoline).
- Developing a more extensive ethanol fueling infrastructure, which would enable the state to operate more of its flexible fuel vehicles on E85 (85 percent ethanol and 15 percent gasoline) rather than on gasoline.
- Switching to E10 (10 percent ethanol) for the rest of the state government's vehicle fleet.
- Creating stronger incentives for the incorporation of hybrid technology and very fuel efficient vehicles.

3) Purchase 20 percent of state government's electricity from clean renewable sources by 2015 and 50 percent by 2025.

Under Governor Napolitano's direction, state agencies have been increasing their use of renewable energy. In a February 2005 executive order, Governor Napolitano instructed all state-funded buildings to use at least 10 percent renewable energy. The Department of Administration also purchases some renewable energy for its government mall facilities.[148] Currently very little of the energy used by state government agencies comes from renewable sources.

Enlisting Arizona state government as an aggressive purchaser of renewable electricity—purchasing 20 percent renewable energy by 2015 and 50 percent by 2025—would provide a critical incentive for the development of solar, wind and other forms of renewable power in the state and region. Government purchases of "green" power should be over and above the levels of renewable power required by the state's Renewable Energy Standard and should include the development of distributed renewable resources on state buildings and land, such as rooftop solar systems where appropriate.

4) Encourage public sector improvements outside of state government.

Educational intuitions (including public schools (K-12), junior colleges, colleges, universities) as well as tribal and municipal governments are major consumers of energy. The state should help promote and drive efforts to reduce carbon dioxide emissions from these institutions. This includes helping to drive improvements in energy efficiency, increasing their use of renewable energy—either through purchasing green power or installing distributive electricity generation such as photovoltaic solar power, and obtain greater market power in the purchase of efficient vehicles and equipment.

The Impact of the Strategies

Short- and Medium-Term Impacts

If Arizona adopted the 14 strategies discussed above, the state could essentially stabilize its global warming pollution despite significant population increases and economic growth. Improved efficiency and reduced energy use in the transportation, residential, commercial, industrial and electricity generating sectors, combined with the increased use of renewable energy, would reduce Arizona's global warming emissions by 77 $MMTCO_2$ or 40 percent below projected levels by 2025. (See Table 1 and Figure 5.)

The policies modeled in this report come close to stabilizing Arizona's emissions at current levels. By adopting other policies discussed but not quantified in this report and considering policy ideas from other sources, Arizona actually reduce emissions below current levels. Action at the federal level in areas in which Arizona's freedom of action is limited also would make greater emission reductions possible.

The strategies presented in this report affect emissions from all categories of energy use in Arizona, including direct consumption of fuel in the transportation, residential, commercial and industrial sectors and energy burned to generate electricity. To reduce overall emissions, rather than to simply stabilize releases or slow the rate of growth in emissions, Arizona will need to adopt additional policies that include all sectors.

As seen in Figure 6a and 6b, the policies in this report have a greater impact on emissions from the electric sector than other sectors. Carbon dioxide pollution from electricity generation is projected to decline if the policies presented here are adopted (Figure 6a). Emissions from other sectors, particularly transportation, are projected to continue rising (Figure 6b). To curb global warming pollution from transportation, Arizona will need to pursue policies that achieve greater reductions in vehicle miles traveled or that reduce per-mile emissions from vehicles.

Figure 5. Arizona's Carbon Dioxide Emissions after Adoption of 14 Strategies Quantified in this Report

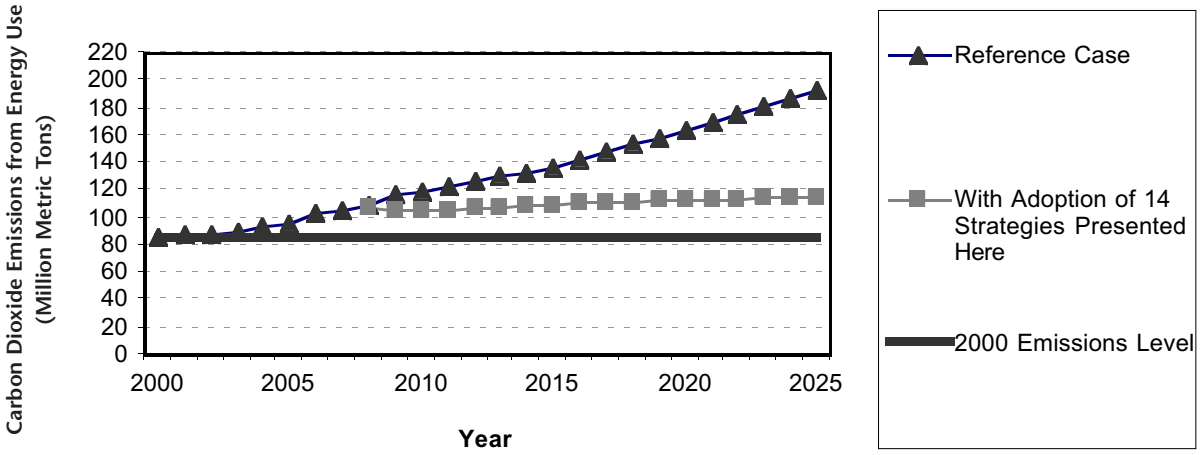


Table 1. Projected Annual Carbon Dioxide Emissions Reductions from Recommended Policy Actions ($MMTCO_2e$)

Policy	2015	2020	2025
Clean Cars Program	2.3	4.7	7.2
Low-Rolling Resistance Replacement Tires	0.6	0.7	0.9
Feebate Program (AZ only)*	0.1	0.1	0.1
Pay-As-You-Drive Automobile Insurance	2.5	2.8	3.2
Reduce Growth in Vehicle Miles Traveled	4.4	7.3	10.7
Renewable Fuels Standard	2.0	3.1	4.9
Expanded Energy Efficiency Programs	3.9	6.4	9.1
Appliance Efficiency Standards	0.6	1.0	1.1
Residential and Commercial Building Codes	2.6	5.0	7.9
Combined Heat and Power	3.8	5.0	4.8
Solar Power Development	0.1	0.2	0.7
Expanded Renewable Energy Standard	8.2	13.4	18.9
Prevent Expansion of Coal-Fired Power Plants	10.1	27.8	47.6
Public Sector Lead By Example	1.5	2.2	3.0
Total	**26.6**	**51.3**	**77.2**

Note: Savings from individual policies do not equal cumulative savings due to some overlap between the policies.

** Savings are likely to be greater from a feebate program that includes multiple states.*

Figure 6a. Arizona's Electric Sector Carbon Dioxide Emissions after Adoption of 14 Strategies Quantified in this Report

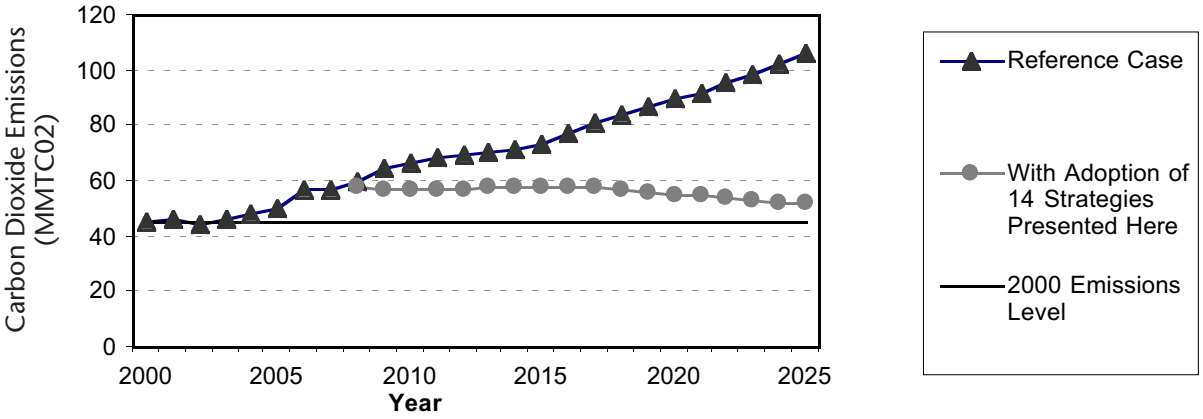
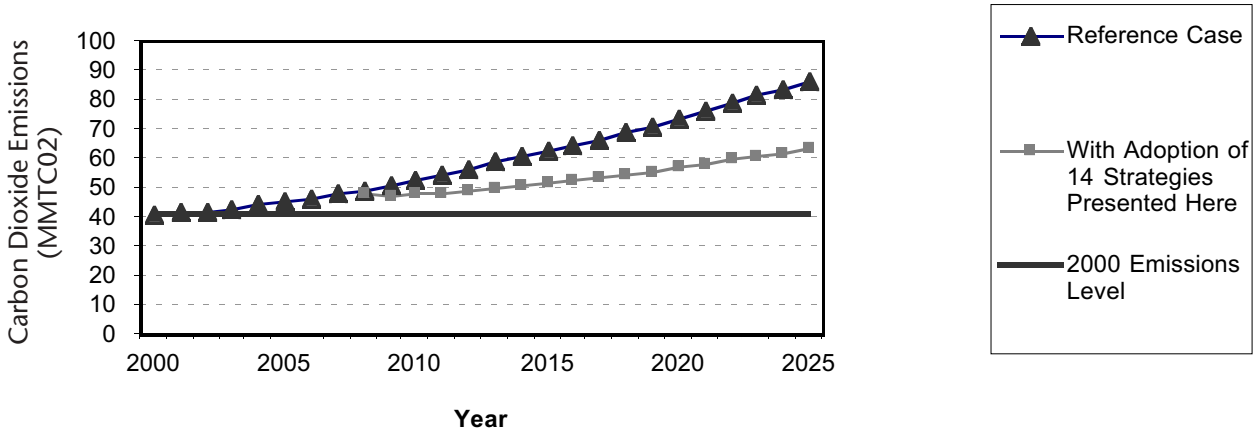


Figure 6b. Arizona's Direct (Non-Electric) Carbon Dioxide Emissions after Adoption of 14 Strategies Quantified in this Report



Putting It in Perspective—Achieving the Long-Term Goal

Ultimately, Arizona's efforts to reduce global warming emissions will be judged not by the state's ability to achieve interim steps, but by the speed with which the state can reduce—and eventually eliminate—its contribution to the degradation of the climate. Achieving the long-term reductions in emissions of 75-85 percent that scientists believe will be needed to eliminate any harmful threat to the climate is the true test by which the state's efforts must be assessed, and should remain the overarching goal.

The 14 strategies above begin to lay the groundwork for a deeper transition that will bring the long-term goals within reach. In the transportation sector, swift implementation of a clean cars requirement will ensure the placement of thousands of high-efficiency and zero-emission vehicles on Arizona's roads, while helping to focus the research energy of automakers on the development of the next generation of clean automobile technologies. The vehicle global warming emission standards program will create the regulatory framework to ensure that all vehicles make the least possible impact on the climate. New buildings will be designed to reduce energy consumption and will house more energy efficient appliances. Owners of existing buildings and appliances will be able to take advantage of energy efficiency programs to reduce their energy consumption. Solar, wind and other renewable power sources will produce 30 percent of the electricity in Arizona, while fuel cells and other new technologies will be market-ready and prepared to compete with traditional fossil and nuclear electricity.

Even with these advances, Arizona will still face difficult challenges. Our communities will have to be reshaped to rely less on individual cars and trucks to transport people and goods. Our buildings will have to be designed to minimize their reliance on fossil fuels. Our economic system will have to reflect more fully the environmental and public health costs of the energy we use, and provide the capital needed to make the transition to cleaner and more efficient ways of living and doing business. Emissions of other global warming gases will have to be reduced dramatically. And other states, regions and nations far from Arizona will have to do their share as well.

Affecting these changes will require an unprecedented amount of research, discussion, cooperation and political will. The early signs are positive: Arizona is now engaging in the discussion and study of global warming, its impacts, and the means of addressing the problem in a way that it never has before. But the critical test—implementation—lies ahead.

The strategies laid out in this report show the way forward. By using existing technologies and reasonable public policy tools, Arizona can make large strides towards reducing the state's contribution to global warming in the near term, while in many cases improving public health, economic well-being and energy security.

Methodology and Technical Discussion

General Assumptions and Limitations

This report relies primarily on data and projections from the U.S. Energy In formation Administration (EIA) to estimate past, present and future global warming gas emissions in Arizona. Future emission trends in Arizona are, with limited exceptions, based on EIA's projected rates of growth for the EIA's Mountain Region—including New Mexico, Colorado, Arizona, Nevada, Idaho, Utah, Wyoming, and Montana—as a whole. Arizona trends will differ, but the EIA growth projections provide a reasonable approximation of future trends. EIA's projections of future energy use—as published in the *Annual Energy Outlook 2006* (AEO 2006)—are intended to reflect all federal, state, and local legislation adopted as of October 31, 2005.

This analysis focuses exclusively on emissions of carbon dioxide from energy use and production in Arizona. We include emissions from all electricity produced in the state, not just from power consumed in Arizona. The exclusion of other global warming gases from this analysis is not intended to minimize their importance, but is the result of time and resource limitations. This report also limits its scope of analysis to Arizona and does not attempt to estimate "upstream" emissions or any "leakage" of emissions into other states. Thus, our projected emission reductions may understate the full impact of the policies modeled.

All fees, charges and other monetary values are 2006 dollars and are assumed to be indexed to inflation.

Baseline Emissions Estimates

Baseline estimates of carbon dioxide emissions from energy use for 1990 were based on energy consumption data from EIA, *State Energy Consumption, Price and Expenditure Estimates 2001*. To calculate carbon dioxide emissions, energy use for each fuel in each sector (in BTU) was multiplied by carbon coefficients as specified in EIA, *Documentation for Emissions of Greenhouse Gases in the United States 2003*, May 2005.

Adjustments were made for storage of carbon through non-fuel consumption of natural gas and petroleum products using data and following the methodologies described in EIA, *Documentation for Emissions of Greenhouse Gases in the United States 2003*, May 2005.

Carbon dioxide emissions, carbon coefficients and non-fuel sequestration factors for "other petroleum products" as defined in *Energy Consumption, Price and Expenditure Estimates 2001* was derived as follows:

- For 1990, 2000 and 2001, Arizona consumption data (in BTU) for the various components of "other petroleum products" were derived from detailed, state-specific energy use data downloaded from EIA's State Energy Data System (SEDS) on 15 August 2005.
- Specific carbon coefficients and percentages of carbon stored through non-fuel use of the products were applied to seven high-use products within the "other petroleum" category to produce an estimate of carbon dioxide emissions for each product. Any remaining consumption was applied a generic carbon coefficient of 73 $MMTCO_2e$ per quad BTU and a carbon emission per unit fuel consumed factor of 0.4.
- These emission estimates were then aggregated and divided by the total consumption of the various products to produce a per-BTU coefficient used to estimate carbon dioxide emissions from the "other petroleum products" line item in *State Energy Consumption, Price and Expenditure Estimates 2001*. The coefficient for 2001 was used to calculate emissions in subsequent years.

Combustion of wood and other biomass was excluded from the analysis per EIA, *Documentation for Emissions of Greenhouse Gases in the United States 2003*. This exclusion is justified by EIA on the grounds that wood and other biofuels obtain carbon through atmospheric uptake and that their combustion does not cause a net increase or decrease in the overall carbon "budget."

Future Year Projections

Projections of energy use and carbon dioxide emissions for Arizona are generally based on applying the Mountain Region year-to-year projected growth rate for each fuel in each sector from EIA's *Annual Energy Outlook* to the Arizona baseline emissions estimate for 2001. The growth rate from 2001 to 2002 is based on *AEO 2005*; growth rates for subsequent years are based on *AEO 2006*.

There are several exceptions to this rule:

- Energy consumption and carbon dioxide emissions from the residential, commercial and industrial sectors were adjusted upward to account for differences in projected population growth rates between Arizona and the Mountain region as a whole. The annual growth rate in energy consumption from *AEO 2006* was multiplied by 1.008, or the ratio of Arizona's projected annual rate of population growth for 2005 through 2025 to the regional population growth rate in *AEO 2006*. The Arizona population growth rate was derived from U.S. Census Bureau, Population Division, *Interim State Population Projections*, 2005.
- Projected growth in the use of gasoline and diesel for transportation was based on data presented in Cambridge Systematics, Inc., for Arizona Department of Transportation, *MoveAZ Plan: Long-Range Transportation Plan*, September 2004.
- An Arizona-specific growth rate for renewable electricity generation was

calculated to reflect the goals and targets of the state's proposed Renewable Energy Standard. Adjustments to baseline energy use by electric generators were made based on the methodology described in "Renewable Energy Standard" below.

Our baseline projections are consistent with those presented in Center for Climate Strategies, *Arizona Greenhouse Gas Inventory and Reference Case Projections 1990-2020*, March 2006. Both the reference case scenario created for this document and the reference case in *Arizona Inventory* project a significant increase in global warming pollution over the next decade and a half. According to the reference case used in this document, Arizona's emissions of carbon dioxide from energy use can be expected to increase by approximately 62 percent between 2000 and 2020 while *Arizona Inventory* projects an increase of 66 percent in all global warming emissions.

Carbon Dioxide Reductions from Electricity Savings and Renewable Energy Use

Measures that reduce electricity consumption in Arizona or that expand renewable electricity generation were assumed to reduce the generation of fossil electric power in Arizona by an equivalent amount. Further, these reductions were assumed to result in an equivalent reduction in generation from coal-fired power plants, which are projected to make up most of the new generating capacity installed in Arizona, particularly after 2015.

Reductions in carbon dioxide emissions from energy efficiency measures were calculated as follows:

- Reductions in site electricity consumption were calculated as described in the sections below.
- Reductions in energy consumption for electricity generation were calculated by multiplying the site electricity savings of efficiency measures by the ratio of fuel consumption (in BTU) for each fossil fuel to electricity generation for power plants in the Western Electricity Coordinating Council—Rocky Mountain Power Area and Arizona-New Mexico-Southern Nevada Power Area from *AEO 2006*, Supplementary Table 71. The resulting reductions in power plant fuel use were then deducted from the baseline projected fuel use as calculated above.

Transportation Sector Strategies

All estimated reductions from transportation-sector strategies (except biodiesel use in heavy-duty vehicles) were derived by estimating the percentage reductions in light-duty vehicle motor gasoline use from the baseline arrived at by the methods above. Light-duty vehicle gasoline use was estimated by multiplying the motor gasoline baseline by the percentage of motor gasoline used by light-duty vehicles, derived from the supplementary tables to *AEO 2006*.

Clean Cars Program

Emission reductions from the clean cars program were estimated based on percentage year-to-year emission reductions from Arizona PIRG Education Fund, *Cars and Global Warming*, February 2006. The Arizona PIRG Education Fund report uses national estimates of the breakdown of VMT among various vehicle classes and ages, as well as an implementation schedule for the program that is consistent across all states that have thus far adopted the program. The results of that analysis have been

consistent with estimates of the benefits of the program produced for other states. Program implementation was assumed to begin with model year 2011.

Low-Rolling Resistance Tires

Savings from the use of low-rolling resistance replacement tires were estimated using a methodology developed for RIPIRG Education Fund, *Cars and Global Warming*, Winter 2005. Emission reductions were generated by reducing carbon dioxide emission factors by 3 percent from baseline assumptions for vehicles reaching four, seven and 11 years of age beginning in 2008, per California Energy Commission, *California Fuel-Efficient Tire Report*, *Volume II*, January 2003. Vehicle age estimates were based on VMT accumulation rates presented in U.S. Environmental Protection Agency, *Fleet Characterization Data for MOBILE6*, September 2001. This estimate assumes that the tire stock will completely turn over; that is, that LRR tires will supplant non-LRR replacement tires in the marketplace through a state requirement. Other policies to encourage, but not mandate, LRR tires will likely produce reduced savings.

Feebates

Potential savings from a feebate program are based on outputs from the Feebate Impact Estimator v. 1.1 developed by Meszler Engineering Services. Default inputs were adjusted to reflect gasoline tax rates in Arizona (per Federal Highway Administration, *Highway Statistics 2004*) and projected Arizona VMT growth (per Arizona Department of Transportation, *Highway Performance Monitoring System*, downloaded from tpd.azdot.gov/datateam/hpms.php, 25 October 2005). The feebate incentive rate was set to $680 per ton of carbon dioxide per year. The default input for manufacturers' response was adjusted to 0.02 to reflect Arizona's share of new motor vehicle registrations nationwide in 2004, per Alliance of Automobile Manufacturers, *Light Truck Country 2004*. The assumption that manufacturer response would be proportional to the state's share of the new vehicle market is conservative, producing a relatively low impact from the feebate program. Should the manufacturer response to an Arizona feebate be greater, or should Arizona join with other states in development of a feebate program, the reduction in vehicle carbon dioxide emissions would be much greater. To gauge the impact of a greater manufacturer response, an alternate case was run that assumed 100 percent manufacturer response.

Pay-As-You-Drive Automobile Insurance

Estimates of the impact of PAYD insurance are based on the assumption that 80 percent of collisions and liability insurance payments in Arizona would be transferred to a mileage-based system, with participation in the system increasing by 20 percent per year from 2008 to 2012. The average per-mile cost of insurance was computed by multiplying the average expenditure on collision and liability insurance in Arizona in 2003 as reported in *Facts and Statistics: Auto Insurance Expenditures*, *By State (*Insurance Information Institute, downloaded from www.iii.org/media/facts/statbyissue/auto, 27 September 2005) by the total number of light-duty vehicles registered in Arizona from FHWA, *Highway Statistics 2004*. This total expenditure figure was then divided by light-duty VMT derived from adjusted FHWA figures to arrive at an average per-mile cost for liability and collision insurance. This per-mile cost was then multiplied by 0.8 to account for any non-mileage related aspects of liability and collision coverage and to ensure the conservatism of the estimate, yielding an average per-mile charge of 5.1 cents. The estimated reduction in VMT that would result from such a charge was obtained from *Online TDM Encyclopedia: Pay-As-You-Drive*

Vehicle Insurance (Victoria Transport Policy Institute, downloaded from www.vtpi.org/tdm79.htm, 23 August 2005). It was assumed that the decrease in VMT (8.2 percent) for drivers participating in the program would take place beginning immediately upon program implementation in 2008.

VMT Stabilization

VMT increases in this scenario are estimated to reflect half of Arizona's projected rate of population growth between 2005 and 2025, per U.S. Census Bureau, Population Division, *Interim State Population Projections*, 2005.

Renewable Fuels Standard

Emissions reductions from a renewable fuels standard were estimated assuming a 10 percent ethanol standard implemented in 2008 for light-duty vehicle gasoline sold in the state, increasing to 15 percent in 2011, and a 2 percent biodiesel standard for transportation diesel fuel sold between 2008 and 2010, and increasing to 10 percent after 2010. The share of ethanol coming from cellulosic sources is assumed to be 1 percent in the first year of the standard, rising to approximately 4 percent in 2012 and 12.5 percent in 2015, targets recommended for a federal renewable fuels requirement in Nathaniel Greene and Yerina Mugica, Natural Resources Defense Council, *Bringing Biofuels to the Pump: An Aggressive Plan for Ending America's Oil Dependence*, July 2005. The percentage of cellulosic ethanol is assumed to further increase to approximately 25 percent by 2018.

Net per-mile carbon dioxide emission reductions from corn ethanol use were assumed to be 18 percent compared with gasoline, and per-mile reductions from cellulosic ethanol use were assumed to be 85 percent compared with gasoline based on Michael Wang, Argonne National Laboratory, *Updated Energy and Greenhouse Gas Emissions Results of Fuel Ethanol*, PowerPoint presentation to the 15th International Symposium on Alcohol Fuels, 26-28 September 2005. Greenhouse gas emission savings were used in lieu of carbon dioxide savings. Net per-mile carbon dioxide emission reductions from biodiesel use were assumed to be 78 percent per U.S. Department of Agriculture and U.S. Department of Energy, *Life Cycle Inventory of Biodiesel and Petroleum Diesel for Use in an Urban Bus*, May 1998.

Combined Transportation Strategies

Combined emission reduction estimated from the transportation strategies were derived by multiplying the percentage of emissions remaining from each of the strategies by the percentage remaining from the other strategies. The impact of a feebate program is not included in the combined policy case because it is difficult to ascertain how such a program would interact with the carbon dioxide tailpipe standard.

Residential, Commercial and Industrial Strategies

Energy Efficiency Programs

Projections of benefits from energy efficiency programs were based on average savings from existing energy efficiency programs nationwide. For electricity programs, energy savings per percent of utility revenue were obtained from Martin Kushler, Dan York, and Patti Witte, American Council for an Energy-Efficient Economy, *Five Years In: An Examination of the First Half-Decade of Public Benefits Energy Efficiency Policies*, April 2004. For natural gas programs, energy savings were

obtained from Suzanne Tegen and Howard Geller, Southwest Energy Efficiency Project (SWEEP), *Natural Gas Demand-Side Management Programs: A National Survey*, January 2006. Savings from each of the programs included in these studies were plotted on a graph and used to generate a linear equation for the percentage of annual energy use that could be reduced via efficiency per percentage of utility revenue devoted to energy efficiency programs. These equations were then used to generate estimated percentage savings for proposed electricity and natural gas efficiency programs funded with 3 percent of utility revenue. Because there are fewer natural gas efficiency programs and the benefits of these programs vary based on climate and other factors, the percentage savings from natural gas programs was reduced by 25 percent to ensure the conservatism of the estimate.

Future year savings from efficiency measures were assumed to be 90 percent of the first year's annual savings in the first through fourth years after implementation of the measures, 80 percent in years five through nine, 60 percent in years 10-14 and 50 percent afterward. These estimates are arbitrary, but yield maximum "lifetime" savings of about 12 times annual savings by the end of the study period, a rate lower than most estimates of lifetime savings from efficiency programs.

Appliance Efficiency Standards

Estimates of potential energy savings from appliance efficiency standards were based on a recent report by Steve Nadel, et al, American Council for an Energy-Efficient Economy (ACEEE) and the Appliance Standard Awareness Project (ASAP), *Leading the Way: Continued Opportunities for New State Appliance and Equipment Efficiency Standards*, March 2006. Savings were assumed to begin in 2008, increasing in a linear fashion until 2020, and linearly from 2020 to 2025.

Building Energy Codes

The projected impact of building energy codes was derived by estimating the percentage of residential energy use that would take place in new buildings under EIA projections and applying estimated percentage reductions in energy use that would take place under updated codes. Revised codes were not assumed to affect energy use in existing buildings.

The proportion of projected residential energy use from new homes was derived by subtracting estimated energy use from homes in existence prior to 2005 from total residential energy use for each year based on *AEO 2006* growth rates. Consumption of energy by surviving pre-code homes was calculated by assuming that energy consumed per home remains stable over the study period and that 0.4 percent of homes are retired each year, per EIA, *Assumptions to AEO 2005*.

For commercial building codes, commercial building retirement percentages were estimated for states in the U.S. Census Mountain Region by determining the approximate median age of commercial floorspace in the Mountain Region based on data from EIA, *2003 Commercial Building Energy Consumption Survey* (CBECS); estimating a weighted-average "gamma" factor (which approximates the degree to which buildings are likely to retire at the median age); and inputting the result into the equation, *Surviving Proportion = 1/(1+(Building Age/Median Lifetime)^{Gamma}* as described in EIA, *Assumptions to Annual Energy Outlook 2005*. Baseline 2005 commercial energy demand was then multiplied by the percentage of surviving per-code commercial buildings to estimate the energy use from buildings not covered by the code.

Energy savings from stronger energy codes are from Southwest Energy Efficiency Project, *Increasing Energy Efficiency in New Buildings in the Southwest: Energy Codes and Best Practices*, August 2003. Energy

savings from future updates to residential building codes are assumed to be 24 percent beyond *AEO 2006* baseline projections from 2008 to 2010 and 33 percent compared to baseline levels from 2011 to 2025. Commercial savings from 2008 to 2010 were assumed to be 26 percent and 36 percent from 2011 to 2025. Energy savings from updating Arizona's building codes were assumed to take place equally among the various fuels. No attempt was made to estimate the impact of building code revisions on energy use due to renovations of existing commercial and residential space.

Combined Heat and Power

Commercial and industrial power generation from CHP was estimated based on data from Western Resource Advocates, *A Balanced Energy Plan for the Interior West*, 2004. We assumed that the plan's target of 545 MW of new CHP capacity in Arizona by 2014 and 805 MW by 2020 would be realized through incremental additions to CHP capacity beginning in 2008. No additional CHP installations were assumed after 2020. Additional global warming emissions from natural gas consumed in CHP applications were estimated based on a heat rate of 5,000 BTU/kWh and CHP capacity factor of 91 percent, per the Western Resource Advocates report. Emission reductions from centralized power generation were derived using a similar methodology to the other electricity-saving measures in this section.

Electric Sector Strategies

Renewable Energy Standard

The Arizona Corporation Commission has proposed a renewable energy standard that would require 15 percent of the state's energy to come from renewable sources by 2025. We assume this rule will be adopted and have included it in our baseline emission estimates. We then estimated the impact of accelerating and extending the current rate of increase per year to achieve 30 percent renewable energy by the end of 2025. The projected amounted of energy consumed from renewable sources was calculated by multiplying total projected electricity demand in Arizona by the proposed annual increase in the RES.

Solar Program

The impact of expanded solar power in Arizona was estimated by assuming that current and future programs to encourage solar photovoltaic systems would achieve the goal of having the equivalent of 315,000 PV systems installed on residential rooftops by 2025. The number of annual installations was assumed to begin in 2008 with 720 systems of 2.5 kW each. Installations were then assumed to increase by 25 percent each year, an annual rate of growth lower than the annual world growth rate in PV generating capacity per BP, *Statistical Review of World Energy 2005*, 14 June 2005.

Electricity output from this new installed capacity was estimated based on operating at average 25 percent capacity, meaning that a 2.5 kW system generates 5,475 kWh a year (2.5kW x 8,760 hours/year x 25% = 5,475 kWh/year). This is based on average daily solar radiation at locations in Arizona, which ranges from 6.0 to 6.5 kWh/meter-squared—equivalent to full sunlight for 25 to 27 percent of the day. (Renewable Resource Data Center, Department of Energy, *Solar Radiation Data Manual for Flat-Plate and Concentrating Collectors*, downloaded from rredc.nrel.gov/solar/pubs/redbook/PDFs/AZ.PDF, 10 October 2005.)

One-half of the new solar electricity was assumed to count toward fulfillment of RES requirements, the other half to offset fossil fuel-fired generation. All new solar capacity was assumed to be distributed, with no line losses.

Preventing Expansion of Coal-Fired Generation

Emissions savings from preventing the expansion of coal-fired generation were derived by holding carbon dioxide emissions from coal-fired power plants constant at 2008 levels until 2025. Savings from this strategy are likely to be overstated if the coal consumption displaced in this strategy is replaced with other fossil fuels that emit carbon dioxide (such as natural gas), rather than zero-carbon alternatives such as renewable power, energy efficiency, or reductions in power generation for out-of-state sales. In addition, when calculating the combined emission reduction benefits of the 14 strategies, we assume that reductions in electricity use and increases in renewable power generation are used to offset power generation from coal-fired power plants already in existence as of 2008. To the extent that electricity savings and renewable power use offset natural gas generation instead, the carbon dioxide emission reductions in the combined scenario will be reduced.

State Government "Lead by Example"

Emissions savings from state government are based on three categories of action. In each case, we assumed that government energy use does not grow.

Data for electricity and natural gas consumption by Arizona state agencies was obtained from Jim Westberg, Energy Program Administrator, Arizona Department of Commerce, personal communication, 31 March 2006. Data for state government transportation fuel use was not available; thus, we relied on the Federal Highway Administration's figures for gasoline use by non-federal governments from Federal Highway Administration, *Highway Statistics 2004*. As a result, these data represent gasoline consumption by state, county, and local governments. Total statewide diesel use figures are from the same source. We estimated non-federal public sector diesel use by assuming that government diesel use is the same proportion of total diesel use as government gasoline use is of total gasoline use.

To calculate emissions savings from reducing energy use in state facilities by 30 percent by 2015, we multiplied the energy savings for each fuel by its carbon coefficient.

Savings from improving the efficiency of the state's vehicle fleet come from both gasoline and diesel savings. Projected efficiency improvements assume that non-federal government vehicle fleets achieve 20 percent more gallons per mile by 2012 and 30 percent more gallons per mile by 2020. We assumed that there would be no rebound effect of increased miles driven. Carbon savings were calculated by multiplying the energy savings for each fuel by its carbon coefficient.

Carbon savings from having state government purchase 20 percent of its electricity from renewable sources by 2015 and 50 percent by 2025 relied on data we obtained as described above. The calculations assume that the state has already reduced its energy use. The carbon output of the non-renewable electricity assumes that renewable power generation allows the retirement of high-emission coal plants.

Glossary of Acronyms

ACEEE	American Council for an Energy-Efficient Economy
CAFE	Corporate average fuel economy standards
CARB	California Air Resources Board
CHP	Combined heat and power
DG	Distributed generation
EEM	Energy-efficient mortgage
EIA	U.S. Energy Information Administration
FHWA	U.S. Federal Highway Administration
GAO	U.S. Government Accountability Office
GREET	Greenhouse Gases, Regulated Emissions and Energy Use in Transportation model
IGCC	Integrated gasification combined cycle
LRR	Low rolling resistance
MMT	Million metric tons
MMTCE	Million metric tons carbon equivalent
$MMTCO_2(e)$	Million metric tons carbon dioxide (equivalent)
MPG	Miles per gallon
NAS	National Academy of Sciences
PAYD	Pay-as-you-drive
PAYS	Pay-as-you-save
PV	Photovoltaic
RGGI	Regional Greenhouse Gas Initiative
RES	Renewable energy standard
SUV	Sport utility vehicle
SWEEP	Southwest Energy Efficiency Project
VMT	Vehicle-miles traveled

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